Appendix F. System Potential Vegetation Methods and Results

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Appendix F. System Potential Vegetation Methods and Results

Report prepared by:

Peter Leinenbach, Landscape Ecologist, Region 10, USEPA
and
Leigh Woodruff, Environmental Scientist, Region 10, USEPA

Overview

Appendix F is divided into two sections. The first section provides information and analysis about factors associated with the current stream temperature conditions in the South Fork Clearwater River Subbasin. The second section presents potential land cover condition information and data previously developed for this subbasin. This section also presents the methods utilized in this total maximum daily load (TMDL) to develop an understanding of expected (or potential) vegetation land cover conditions, which included an accounting of natural disturbance processes. The final section of this appendix illustrates the methods used to develop "system potential effective shade" estimates, which are applied in this TMDL as "surrogate measures."

Current Condition Assessment

Summary - Stream Parameters that Control Temperature Change

Riparian vegetation, stream morphology, hydrology, point source discharge, climate, and geographic location influence stream temperature. While climate and geographic location are outside of human control, riparian condition, channel morphology, hydrology, and point source discharges are affected by human activities. Specifically, the elevated summertime stream temperatures attributed to anthropogenic sources within the South Fork Clearwater River Subbasin result from the following:

- Riparian vegetation disturbance reduces stream surface shading via decreased riparian vegetation height, width, and/or density, thus increasing the amount of solar radiation reaching the stream surface.
- Riparian vegetation disturbance results in increased temperatures in the microclimate around the stream resulting in increased heating of the water.
- Localized channel widening (increased wetted width to depth ratios) increases the stream surface area exposed to energy processes, namely solar radiation and long-wave radiation.
- Point source discharges directly increase instream temperatures via mass transfer.

Ultimately, these factors affect the energy (thermodynamic) processes within the river. A brief description of stream thermodynamic processes that control temperature change is presented in Appendix I.

Riparian Vegetation – Current Condition

A summary of current vegetation conditions for the South Fork Clearwater River Subbasin is discussed in the *South Fork Clearwater River Landscape Assessment, Volume I – Narrative* (USDA 1998) and is presented below. These conclusions were developed from the review of historical and existing data and were intended to provide a brief summary of landscape conditions and associated trends.

> "The summary of vegetation conditions can best be addressed by identifying the ecological processes that have most changed: alteration of terrestrial disturbance regimes and introduction of nonnative species.
>
> Fire suppression has resulted in more advanced successional states in the subbasin. This is shown by increases in medium and large tree classes in most settings, and reductions in young tree classes and shrublands or montane parkland. Shade tolerant species like grand fir and subalpine fir have increased, while early seral species like lodgepole pine, ponderosa pine, and whitebark pine have decreased. Stand densities have probably increased over historic in some settings (VRU 3 and 4) with consequent increased risk of insect and disease activity and more severe fire. Old growth is probably more abundant than historically, basin-wide, but has declined in ponderosa pine types and increased in mixed conifer and spruce-fir types. In moist grand fir settings (VRU 7 and 10), some fragmentation and isolation of old growth has occurred.
>
> Timber harvest has not replicated the frequency, scale, or kind of historic disturbance. Across watersheds, vegetation conditions are more uniform. Within stands, vegetation structure has been simplified through clearcutting and removal of fire tolerant ponderosa pine and larch. Heterogeneity of disturbance size and stand structure have been lost in many harvested areas. Harvest and fire suppression have resulted in loss of large patches of fire-killed trees, and large snags of long lasting species like larch.
>
> The introduction of nonnative species has highly altered grassland steppe communities. Annual grasses and noxious weeds are well established at low elevations. Fire behavior and soil productivity may change in response to these altered plant communities."

The follow points describing current vegetation conditions were included in the *South Fork Clearwater River Landscape Assessment* (USDA 1998):

- Conversion of foothills grassland on prairie and hill slopes to cropland, hay land, and pasture has been extensive on private lands.

- Annual grasses and noxious weeds have become established on grassland habitat types on low elevation steep south facing slopes.
- Forest succession, fire suppression, and timber harvest have resulted in declines in large open-growth ponderosa pine. Early seral, intolerant species like lodgepole pine and western larch have also declined with fire suppression.
- Patch sizes are smaller on lodgepole sites and larger on moist grand fir sites, when compared to historic conditions.
- Whitebark pine is in serious decline from blister rust, fire exclusion, and mountain pine beetle. Western white pine, never abundant in the subbasin, has also declined from blister rust.
- Grand fir, Douglas fir, and subalpine fir have increased.
- Early seral structural stages, including forest openings, seedling and sapling, and pole stands with snags and down wood, have decreased because of fire suppression. Medium and large tree classes have increased in most areas, except for larch and ponderosa pine forests.
- Large patches of fire-killed snags have declined with fire suppression. Numbers of large diameter snags have declined where timber harvest has occurred.

Current Vegetation Land Cover Condition Data

A geographical information systems (GIS) coverage of the current vegetation land cover condition, called Pi_stratum, was obtained from the Nez Perce National Forest (NPNF). Specifically, the Pi_stratum is a six-digit code designed to stratify timber stands based on aerial photo interpreted properties for timber stand sampling and extrapolation. Figure F-1 illustrates an example area along the South Fork Clearwater River main stem, where the Pi_stratum coverage was overlaid onto a digital ortho quad photograph. The specific codes associated with the Pi_stratum are presented in Table F-1 and the six-digit code is illustrated in Figure F-1. This coverage is available for the entire subbasin. Figure F-2 illustrates assigned species composition within the Pi_stratum data set.

Figure F-1. Example of Pi_stratum Vegetation Land Cover Classification

Pi_stratum current land cover data are coded for species type, canopy density, and size/structure. Species type is coded according to the dominant existing over-story species. Canopy density is presented as the percentage of ground that is covered by over-story vegetation when viewed from directly above or measured by a densiometer at ground level. Size/structure classes are divided by diameter at breast height (dbh) for woody vegetation.

Vegetation Size Class Distribution Summary from the Pi_stratum Data Set

Figure F-3 illustrates the land cover distribution by vegetation size class for a 300-meter buffer surrounding the South Fork Clearwater River within the NPNF (approximately river miles 63.9 through 24.4) and areas below the NPNF boundary. These areas roughly correspond with the two different temperature regimes observed in this river (see Chapter 2). A much higher proportion of larger trees (expressed as dbh) are present within the NPNF reach. This area of the river does not exhibit a large temperature increase. The greater percentage of smaller trees within the non-NPNF areas results in lower shade potential (i.e., a shorter object will tend to produce a lower shade horizon.) Similarly, a higher proportion of the “non-stocked with trees” category is present within the lower reach. The percentage of roads within the 300-meter buffer is approximately similar between the two reaches. A very large percentage (>50%) of near-stream areas in the lower reach are covered with “tree” vegetation.

Table F-1. Nez Perce Pi_stratum codes legend (NPNF 2001).

Digit 1 – Status	Digit 2 - Condition
1 - non-forest (potential)	0 – water
2 – forest	1 - land (unproductive)
	2 - incapable (forest but can't produce marketable products)
	3 - Capable (forest and can produce marketable products)
Digit 3 - Species Composition	**Digit 4 - Size Class**
0 – not stocked with trees	0 – not stocked or not applicable
1 – ponderosa pine/Douglas fir	1 - seedling/sapling (to 4.9 inch dbh)*
2 – lodgepole pine	2 - poles (5.0 - 8.9 inch dbh)
3 – subalpine fir	3 - small saw (9 - 13.9 inch dbh)
4 - mixed conifer	4 - large saw (14.0 – 20.9 dbh)
5 - white bark pine	5 – big tree (21 inch or greater dbh)
6 - bracken/coneflower	
Digit 5 – Vertical Structure	**Digit 6 - Crown Closure**
0 - single storied stand	0 - 0-10%
1 - two storied stand	1 - 10-40%
	2 - 40-70%
	3 - >70%

*diameter at breast height

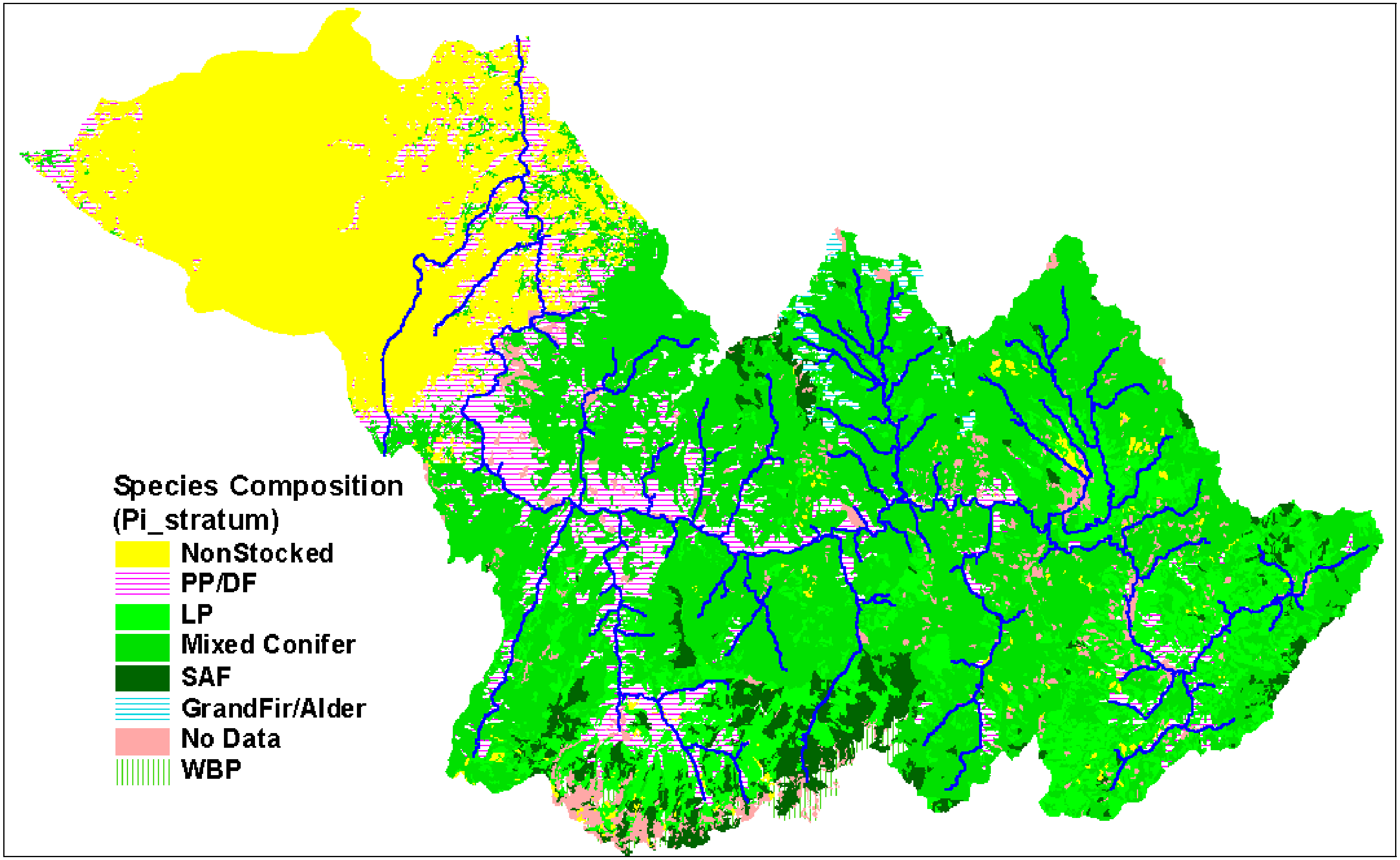
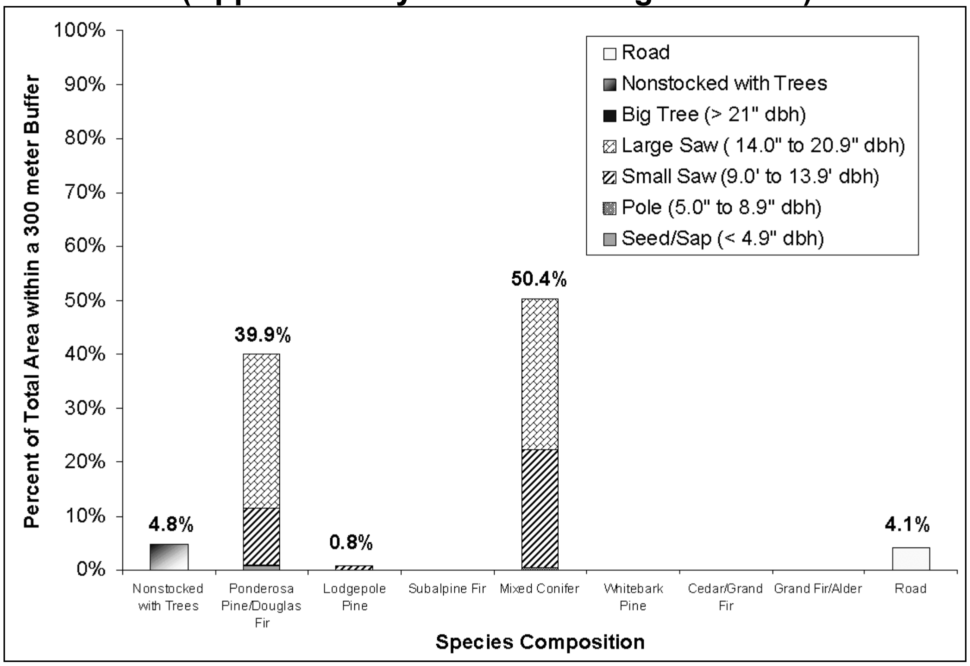


Figure F-2. Current Vegetation Species Composition within the South Fork Clearwater River Subbasin

NPNF Lands (Approximately RM 63.9 through RM 24.4)



Non-NPNF Lands (Approximately RM 24.4 through mouth)

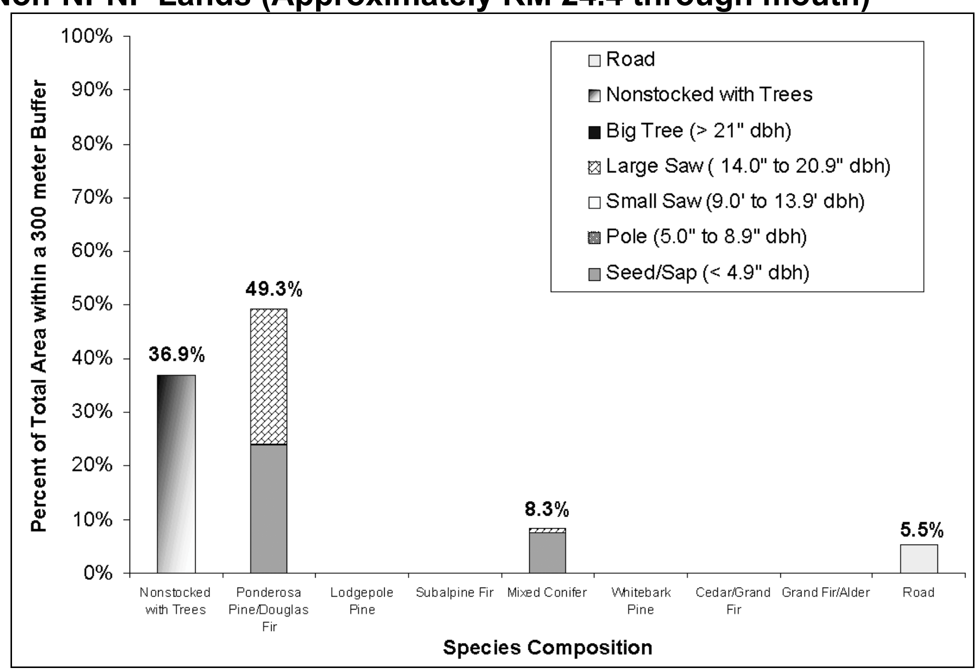


Figure F-3. Near-Stream Vegetation Size Classes within a 300-Meter Buffer of the South Fork Clearwater River within Nez Perce National Forest Lands (upper) and Below Nez Perce National Forest Lands (lower)

Field Measured Vegetation Condition

Near-stream vegetation conditions were measured by the NPNF during the past decade. Diameter at breast height, vegetation height, and condition were measured for 1,870 trees. Figure F-4 illustrates the distribution of observed tree height and dbh, separated by species, for all observed (non-snag) trees included in this study. Table F-2 presents calculated percentile information for this data.

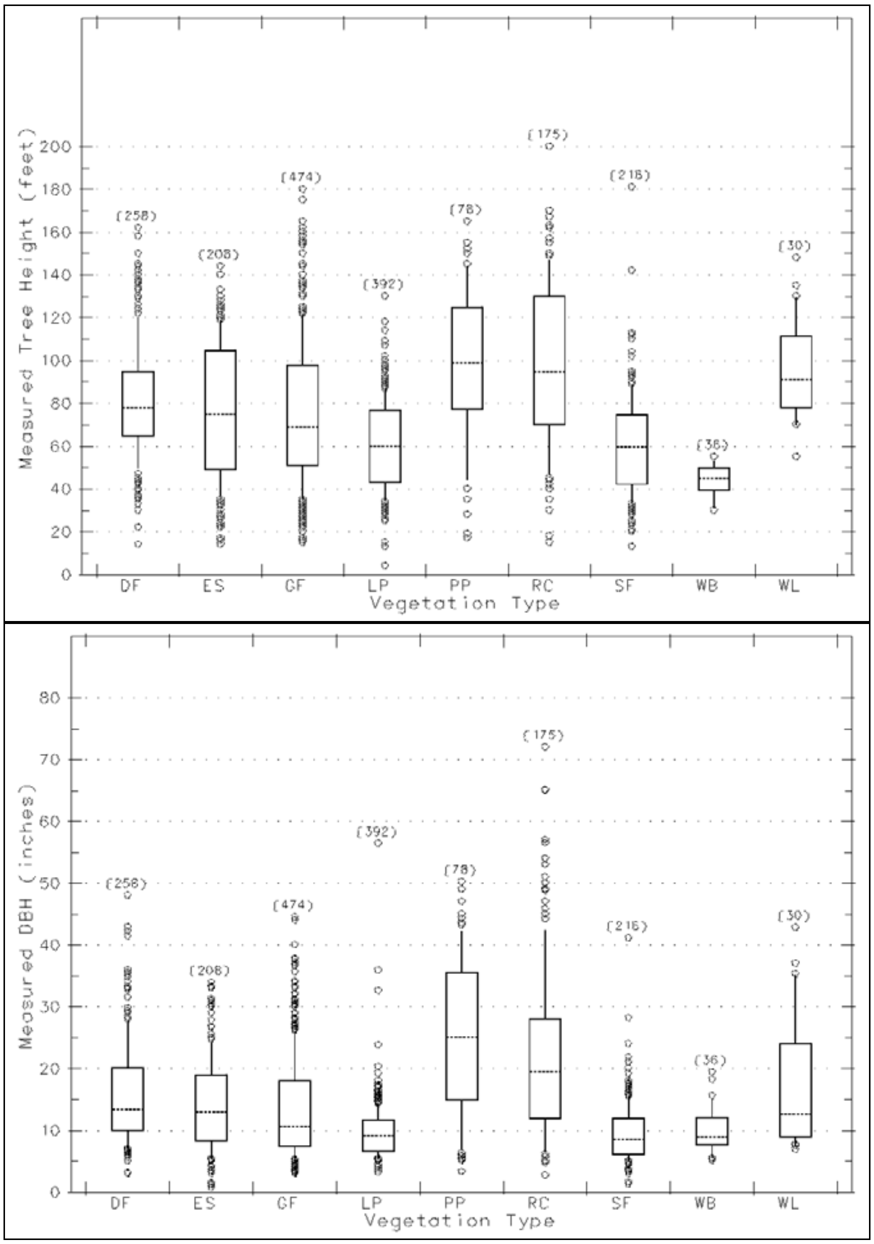


Figure F-4. Measured Tree Heights and Diameter at Breast Height Conditions within the Nez Perce National Forest (NPNF 2002)

Table F-2. Current condition percentile summary for the Nez Perce National Forest.

Tree Height Percentile Summary										
Vegetation Type	**N**	**1%**	**5%**	**10%**	**20%**	**50%**	**80%**	**90%**	**95%**	**99%**
Douglas Fir	258	27	40	50	60	78	100	120	138	153
Engelmann Spruce	208	16	30	37	45	75	108	118	124	139
Grand Fir	474	17	27	36	48	69	104	121	140	161
Lodgepole Pine	392	24	30	35	40	60	80	87	92	109
Ponderosa Pine	78	17	28	45	74	99	131	144	150	165
Western Red Cedar	175	17	39	47	60	95	133	147	151	177
Subalpine Fir	216	20	29	34	40	60	81	88	95	142
Whitebark Pine	36	30	30	31	38	45	50	53	55	55
Western Larch	30	55	63	70	76	91	117	130	141	148
–Diameter at Breast Height Percentile Summary (inches)										
Vegetation Type	**N**	**1%**	**5%**	**10%**	**20%**	**50%**	**80%**	**90%**	**95%**	**99%**
Douglas Fir	258	4.2	5.6	7.1	9	13.4	22.3	27.7	33	42.5
Engelmann Spruce	208	1.1	4.1	5.5	7.2	13	20.4	24.2	30	33.3
Grand Fir	474	3.3	5	5.4	6.8	10.7	20.5	26	30.1	37.7
Lodgepole Pine	392	4.4	5.1	5.5	6.2	9.1	12.3	14.3	16	24.4
Ponderosa Pine	78	3.3	5.4	6.9	12.5	25	39	42.2	45.1	50.2
Western Red Cedar	175	4.2	5	6.6	9	19.5	30	42.3	51.4	66.8
Subalpine Fir	216	1.8	4.8	5.2	5.9	8.6	13	15.4	17.7	27.5
Whitebark Pine	36	5.1	5.3	5.7	7.4	8.9	13	15.1	18.4	19.4
Western Larch	30	6.9	7.2	7.7	8.4	12.6	26.1	35	39.6	42.8

*N = number of trees sampled

Species Specific Growth Curves

The ground level data were used to develop species-specific growth curves. Specifically, the data were used to develop second-order polynomial equations for each tree species sampled during these monitoring activities. Calculated second-order polynomial equations provide a reasonable prediction during tree height modeling where tree size (i.e., dbh) falls within the diameter range of the data used to generate equation coefficients (Garman et al. 1995). Table F-3 presents a summary of calculated regression coefficients. It is important to note that snag trees were not included in model development.

$$\text{Vegetation Height} = (a*\text{dbh}^2)+(b*\text{dbh})+(c)$$

Table F-3. Calculated regression coefficients and model information.

	a	b	c	R^2	N
Engelmann Spruce	15.097	5.4849	-0.0658	0.68	208
Douglas Fir	10.765	6.4305	-0.0991	0.65	258
Grand Fir	7.326	6.6186	-0.0857	0.77	474
Ponderosa Pine	26.414	3.8410	-0.0327	0.65	78
Subalpine Fir	9.955	6.3610	-0.0872	0.64	218
Lodgepole Pine	10.728	6.5604	-0.1190	0.49	393
Western Red Cedar	18.63	5.0542	-0.0497	0.70	175
Western Larch	56.778	2.9801	-0.0276	0.66	30
Whitebark Pine	20.955	3.2703	-0.0888	0.37	36

Sampling/Measuring Current Riparian Land Cover

Streams were obtained from GIS coverages at a 1:24K scale. These stream layers were then segmented into data sampling locations (points) at 100-foot intervals. These point data layers form the basis for automated sampling performed using the GIS tool "Ttools[1]". At every distance node (i.e., every 100 feet) along the stream longitudinally, land cover was sampled at 15-foot intervals out to 120 feet from the channel edge on both stream banks. Sampling was conducted at a perpendicular angle from the calculated stream aspect. A total of 18 vegetation samples were taken at each stream distance node (Figure F-5).

The species-specific growth curves presented in Table F-3 were used to assign tree heights based upon the dbh value reported within the P-stratum data set. roads were included in the analysis and locations were obtained from a GIS data layer.

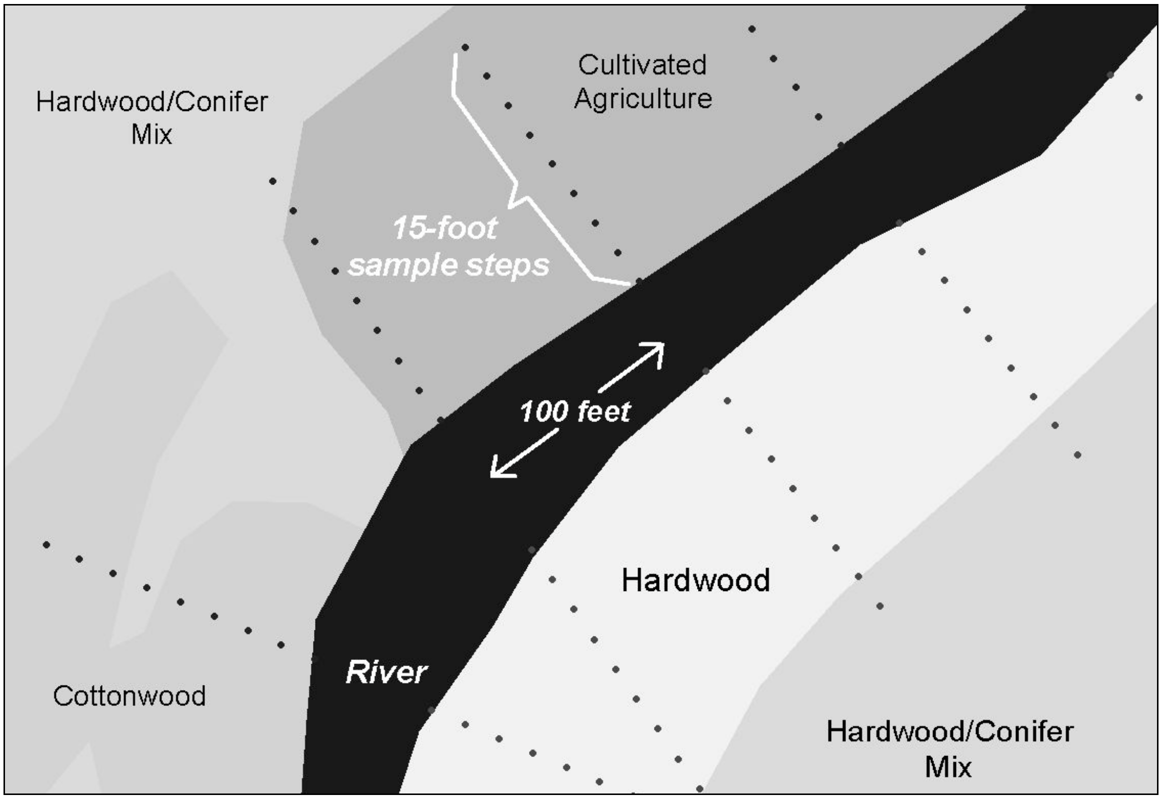
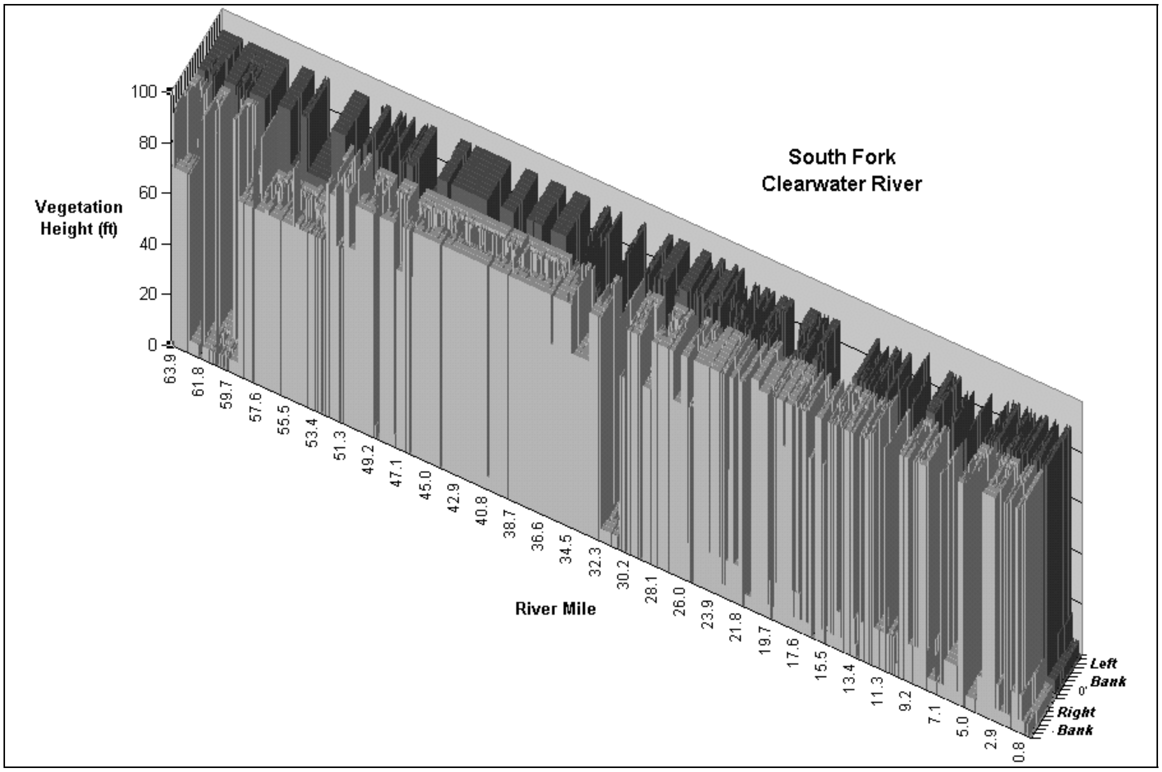


Figure F-5. Example of TTools Automated Vegetation Sampling Methodology

Using the methodology discussed above, current near-stream land cover conditions, as established from the Pi_stratum data set, were sampled for the South Fork Clearwater River, Threemile Creek, Butcher Creek, Little Elk Creek, Big Elk Creek, Elk Creek, Newsome Creek, and Red River. These river systems were chosen for analysis because they are on the 303(d) list and represent examples of a large main stem river system, upper meadow dominated systems, and lower subbasin tributary systems. Current riparian conditions measured within 240 feet of near-stream area (120 feet of each side of the stream) are presented in Figure F-6. Although not included in these images, canopy density of the vegetation cover was included in the Pi-stratum data set and was sampled during this analysis.



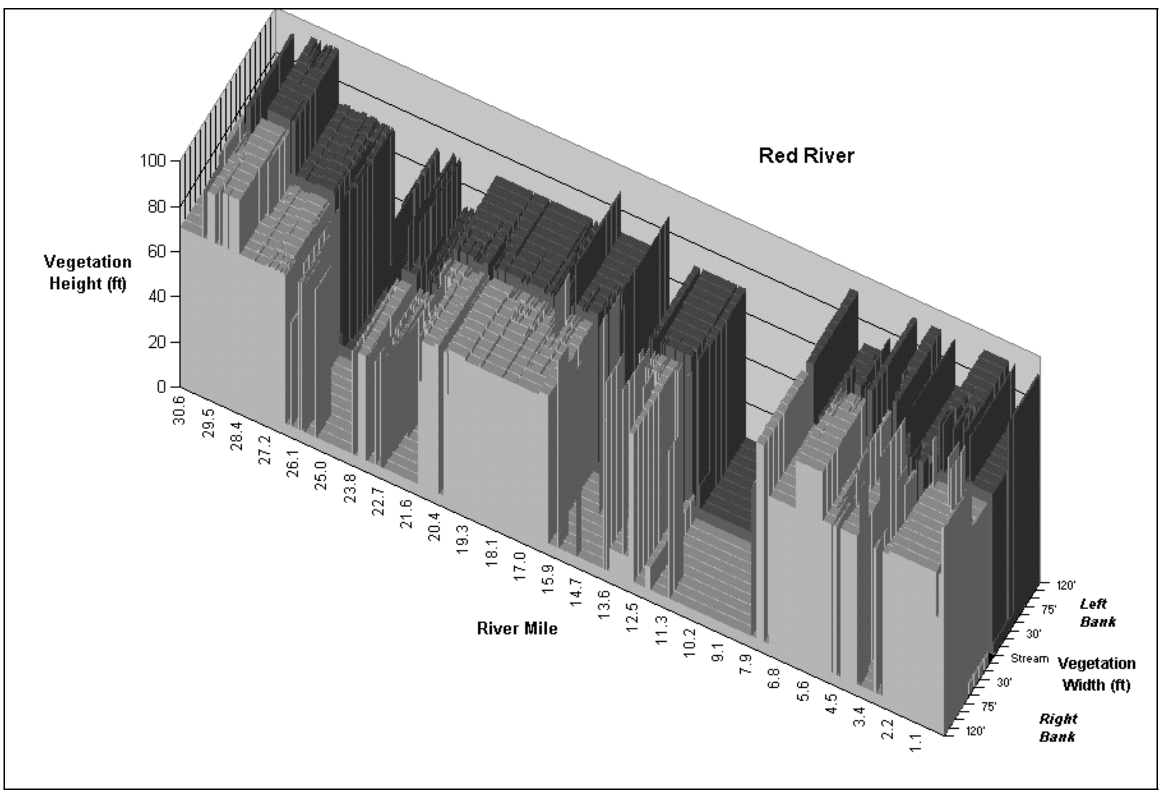


Figure F-6. South Fork Clearwater River and Red River Current Near-Stream Vegetation Condition

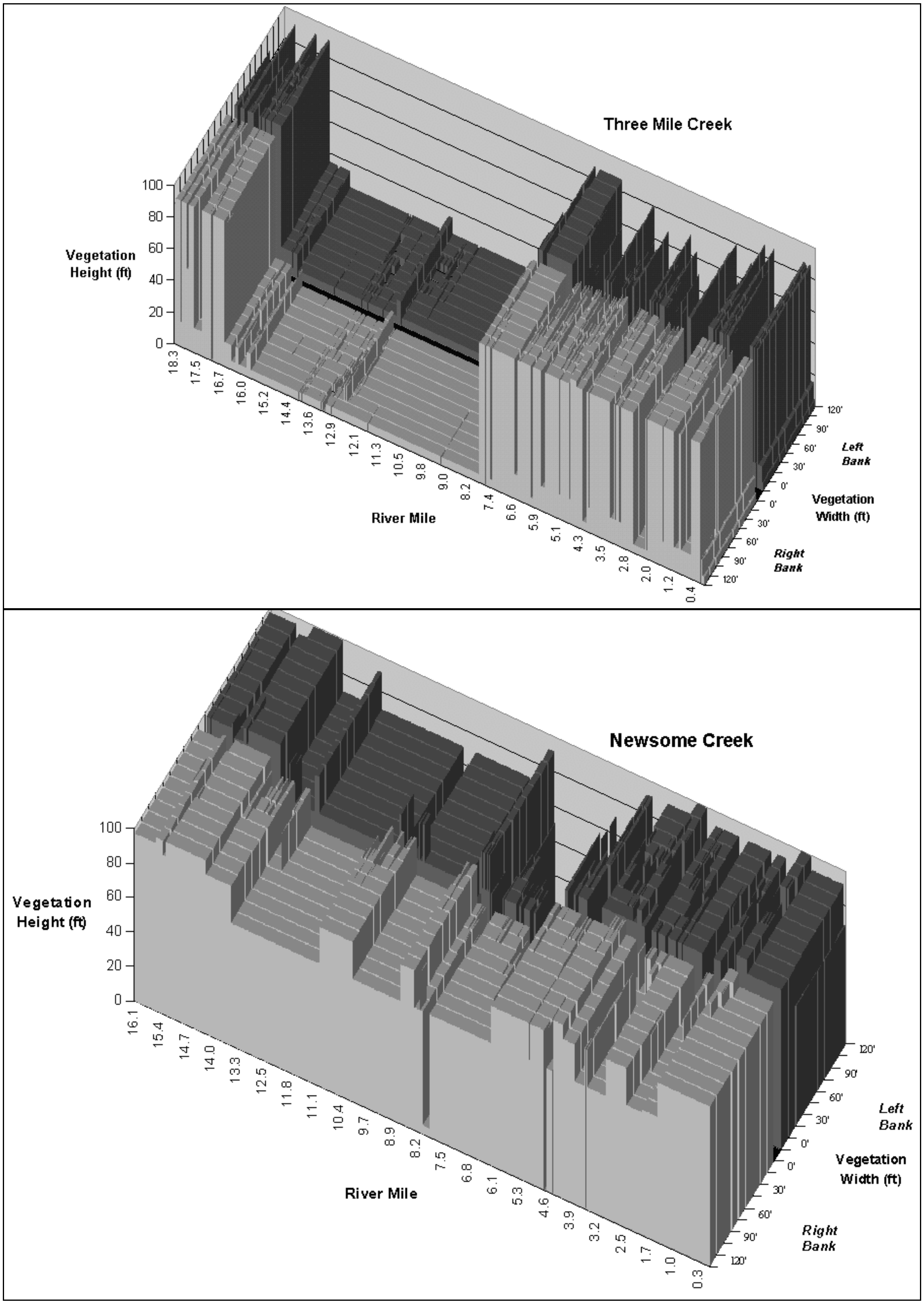
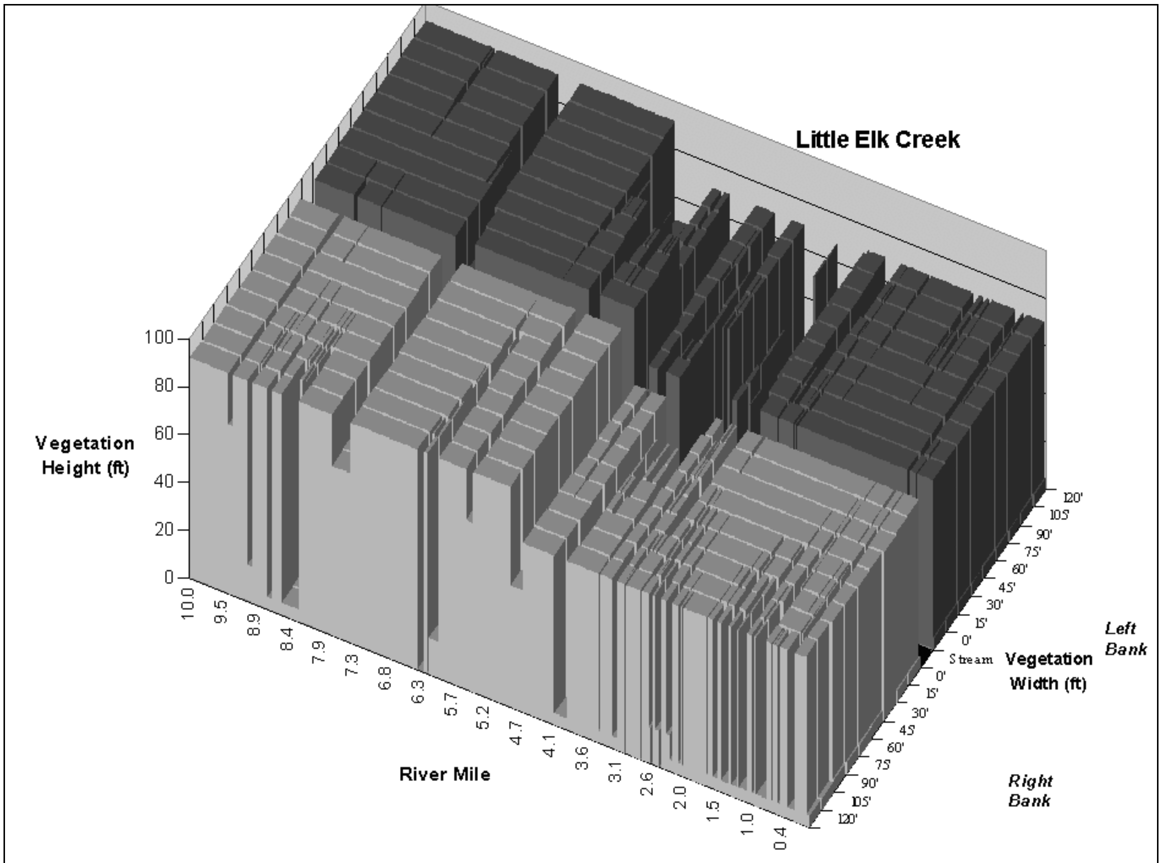


Figure F-6 (continued). Threemile Creek and Newsome Creek Current Near-Stream Vegetation Condition



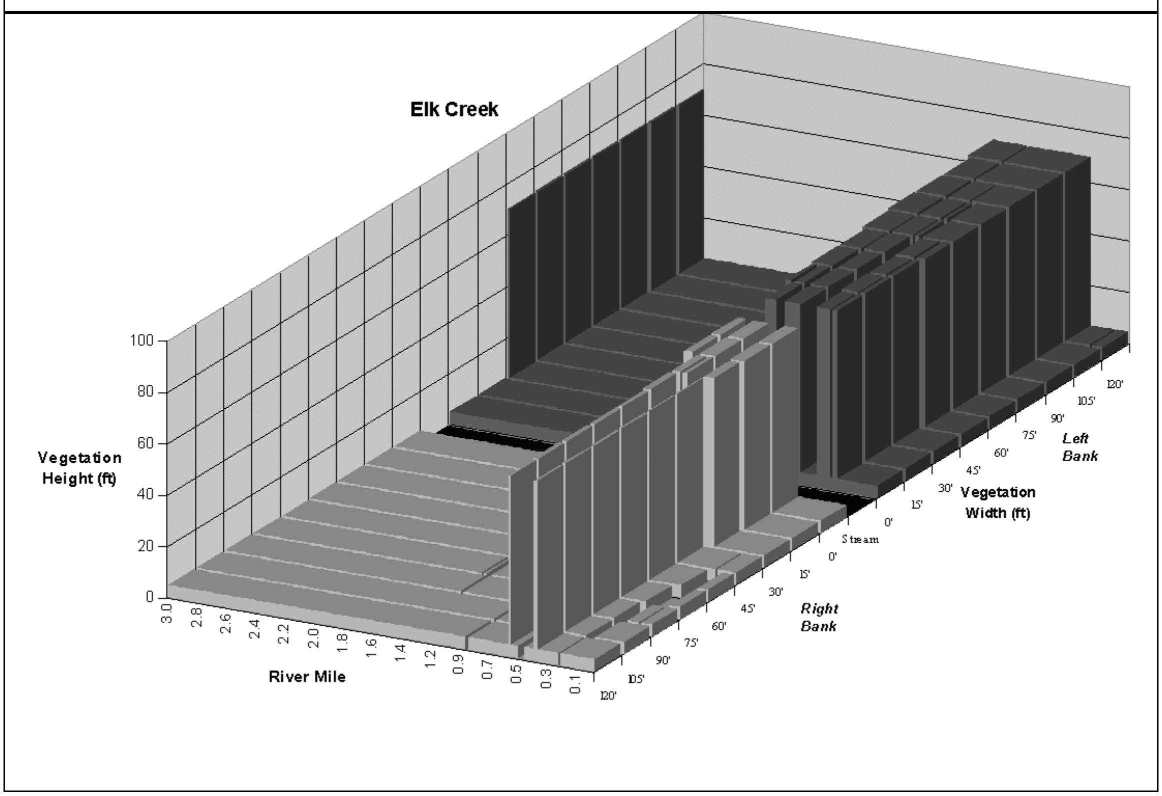


Figure F-6 (continued). Little Elk Creek and Elk Creek Current Near-Stream Vegetation Condition

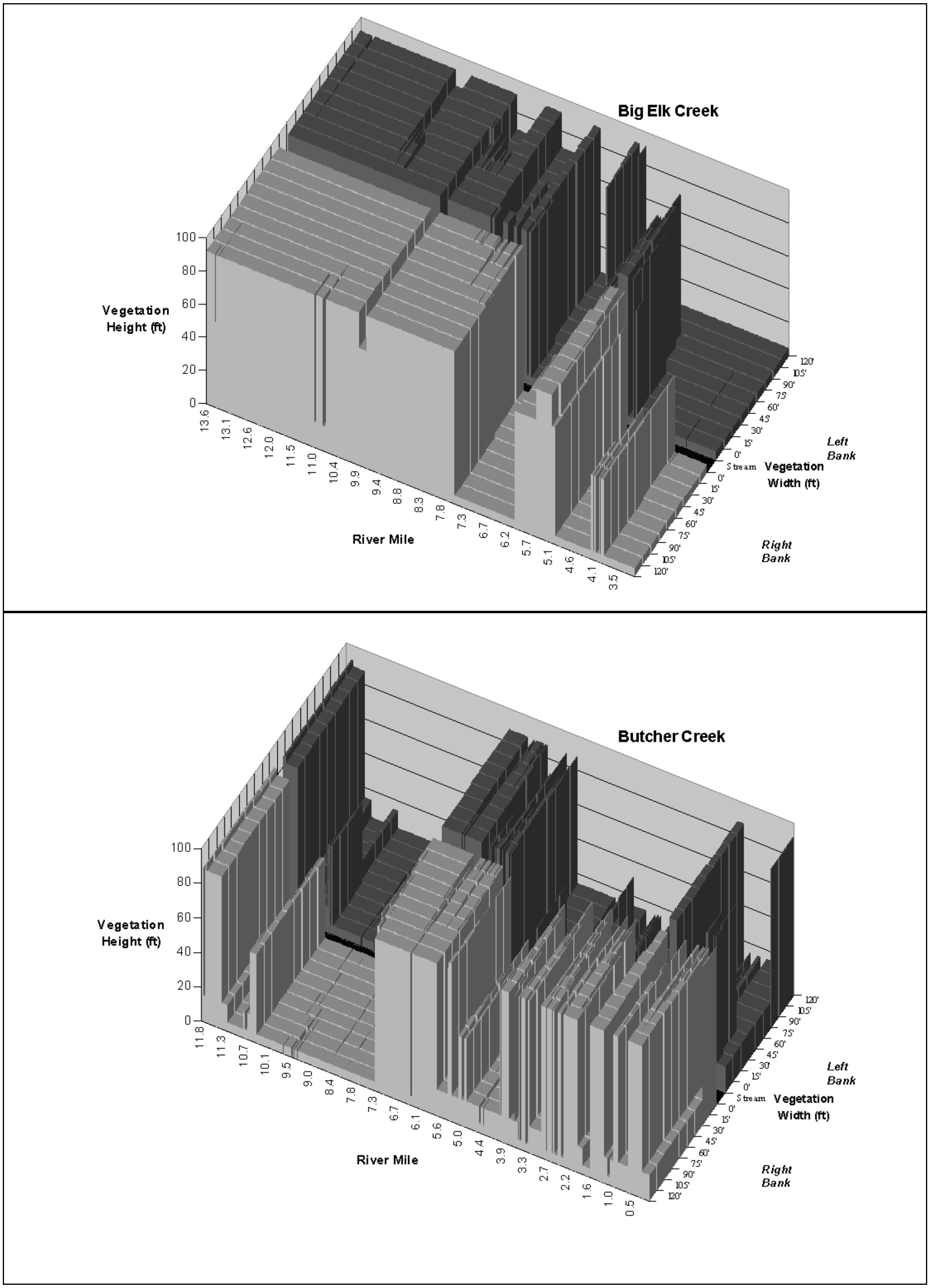


Figure F-6 (continued). Big Elk Creek and Butcher Creek Current Near-Stream Vegetation Condition

Effective Shade – Current Condition

As described in Appendix I, stream shade is defined as the amount of solar energy that is obscured or reflected by vegetation or topography above a stream. Effective shade is defined as the amount of potential solar radiation not reaching the stream surface. Spatial GIS data and point measurements of current vegetation conditions (presented above) were used to calculate current effective shade conditions along streams within the South Fork Clearwater River Subbasin. Current effective shade conditions were calculated using the "Heat Source" shade calculator[2]. This method allows for the incorporation of GIS-derived information to increase the spatial resolution of calculated values.

GIS-Derived Information Used for Effective Shade Calculation

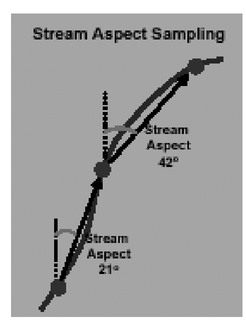
Factors that influence stream shade production along a river are presented in Table F-4. Many of these are directly influenced by human activities, while others are not. Along with topographic shade angle, the parameters listed in this table were used to estimate current effective shade conditions along the South Fork Clearwater River and several tributaries. Using information present within the spatially-explicit GIS data sets dramatically increased the spatial resolution of estimated current effective shade conditions over levels developed from just using point measurements alone.

Table F-4. Factors that influence stream shade.

Description	Parameter
Season/Time	Date/Time
Stream Characteristics	Aspect, **Channel Width**
Geographic Position	Latitude, Longitude
Vegetative Characteristics	**Near Stream Land Cover Height, Width, and Density**
Solar Position	Solar Altitude, Solar Azimuth

Bold type - influenced by human activities

Stream Aspect – Stream aspect was sampled at every stream data node (every 100 feet) using the T-tools (Figure F-7). The stream aspect was calculated as the downstream angle between two stream nodes and north. The units are recorded as degrees from north in the downstream direction. Stream aspect data are used to:
Reference the longitudinal direction and allow the calculation of the transverse direction at each stream data node.
Position the stream relative to simulated surrounding features such as the sun, surrounding near stream land cover, and shade-producing topographic features.



[2] This shade calculator has been used by Oregon Department of Environmental Quality and Washington Department of Ecology during the development of temperature TMDLs during the past several years.

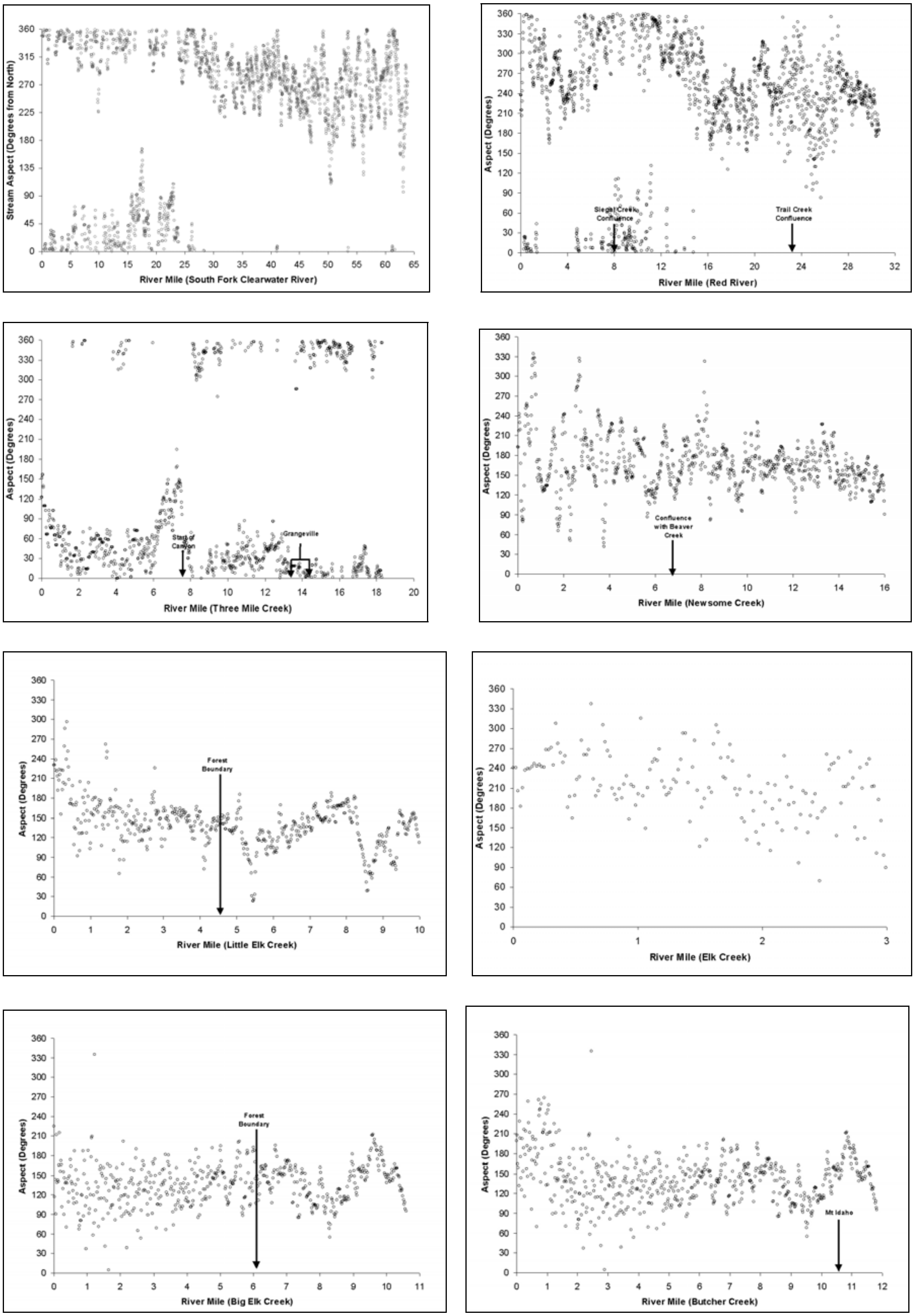
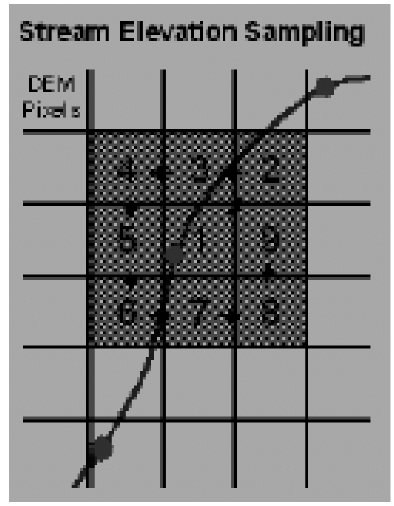


Figure F-7. Stream Aspect

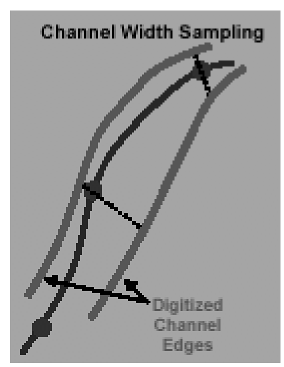
Stream Elevation and Gradient – Stream elevation and gradient were sampled from digital elevation models (DEMs) at each 100-foot model data node using the Ttools. In order to find the lowest pixel nearest to the stream segment node, T-tools samples nine pixels: the pixel that falls directly on the stream segment node and the eight surrounding pixels. The lowest elevation sampled is assigned to the stream segment node. Stream elevation data are used to calculate stream gradients. Both sampled elevation and gradient data are plotted for the aerial extent displayed (Figure F-8). In this fashion, stream elevation and gradient were derived for all stream reaches analyzed. Stream elevation data were used for calculating solar radiation loading and solar position.



$$\text{Stream Gradient} = \frac{\text{Change in Stream Elevation}}{\text{Stream Segment Length}} = \frac{\text{Change in Stream Elevation}}{(\text{\# of Stream Nodes})(\text{Segment Interval})}$$

Topography and Topographic Shade –Topographic features produce shade to the stream system that controls the time of the local sunrise and sunset. Such features include distant mountain ranges, canyons, or other near-stream relief. At each stream data node (every 100 feet), the topographic shade angle was sampled from DEMs to the west, south, and east using TTools. Calculated values are presented in Figure F-9.

Channel Near-Stream Disturbance Zone and Bankfull Width – Near-stream disturbance zone width (NSDZ) is defined for purpose of the TMDL as the width, from left bank to right bank, between shade-producing near-stream vegetation. This distance is often similar to bankfull width. The NSDZ can be measured from digitized channel edge polylines developed from DOQ photographs. At each stream segment node, Ttools measured the distance between the left and right channel edge polylines in the transverse direction (i.e., perpendicular to the aspect). The NSDZ sampling was used for the South Fork Clearwater River (Figure F-10). The bankfull width data were obtained from Department of Environmental Quality sampling of other rivers within the South Fork Clearwater River Subbasin in the summer of 2000 (Figure F-10), where available.



The NSDZ data were used to approximate bankfull width and serve as inner boundaries where transverse near-stream land cover sampling started within Ttools.

The bankfull width and NSDZ width data were used to establish distance between shade-producing features during effective shade calculations.

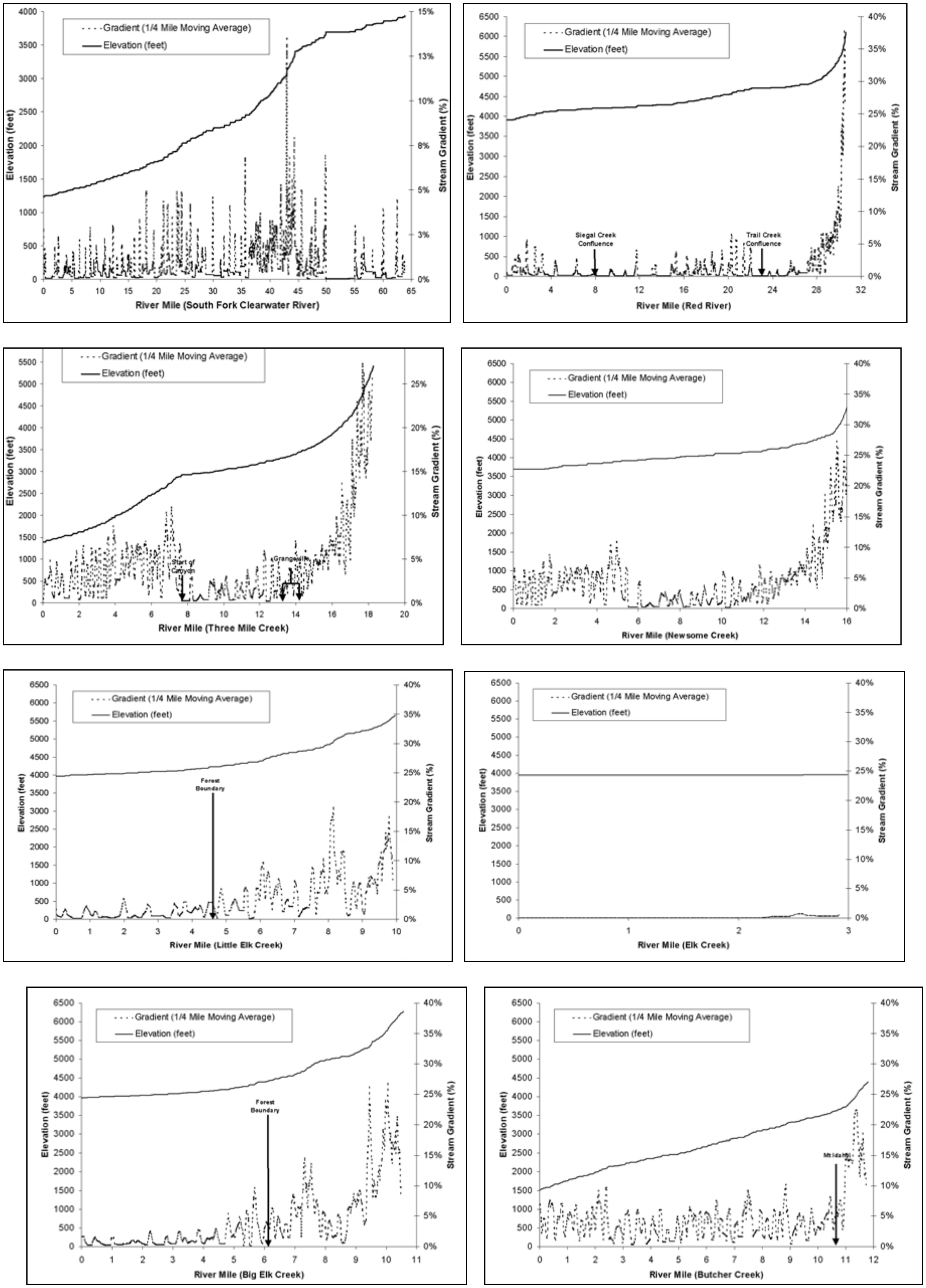


Figure F-8. Stream Elevation and Gradient

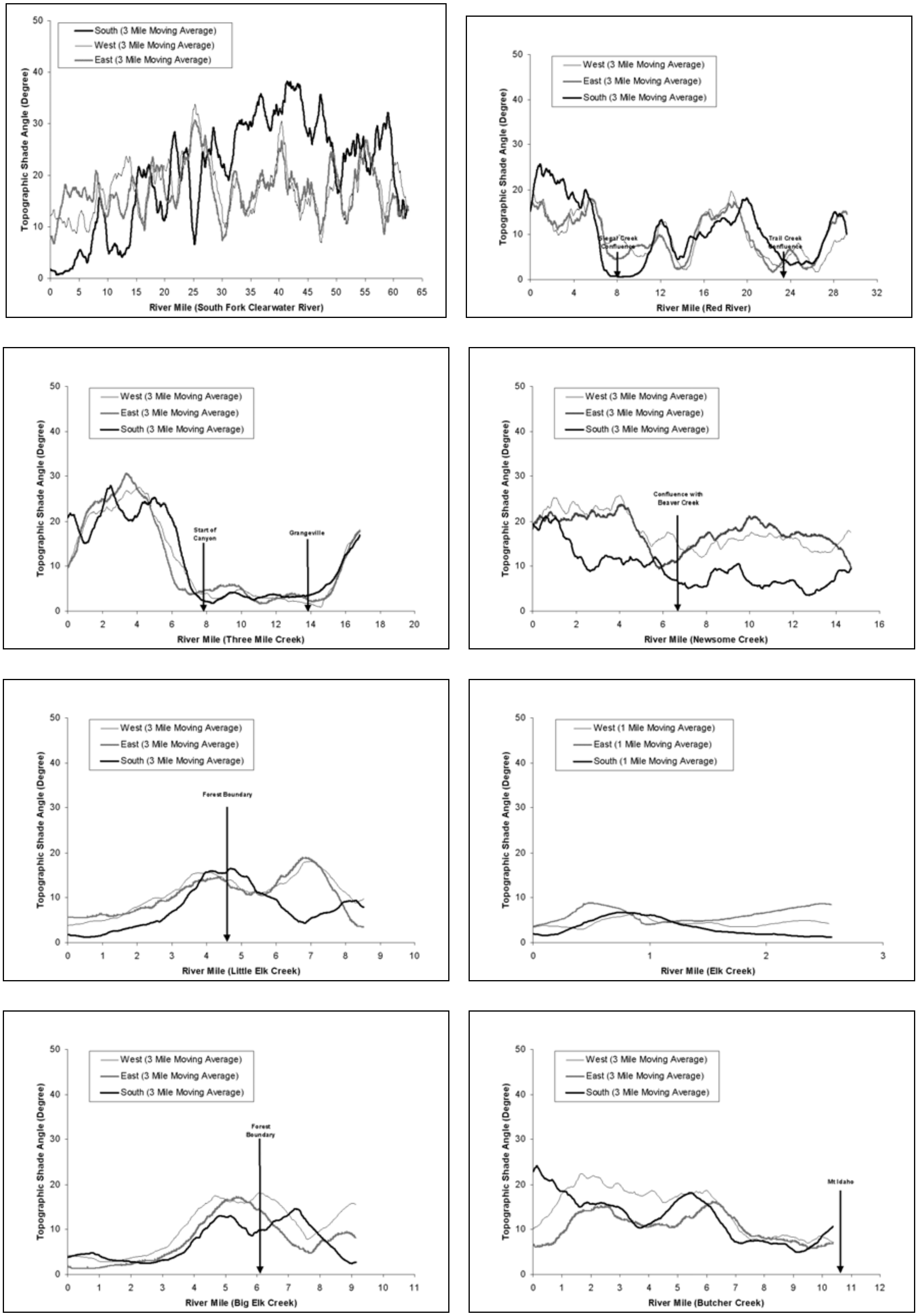


Figure F-9. Topographic Shade Angle

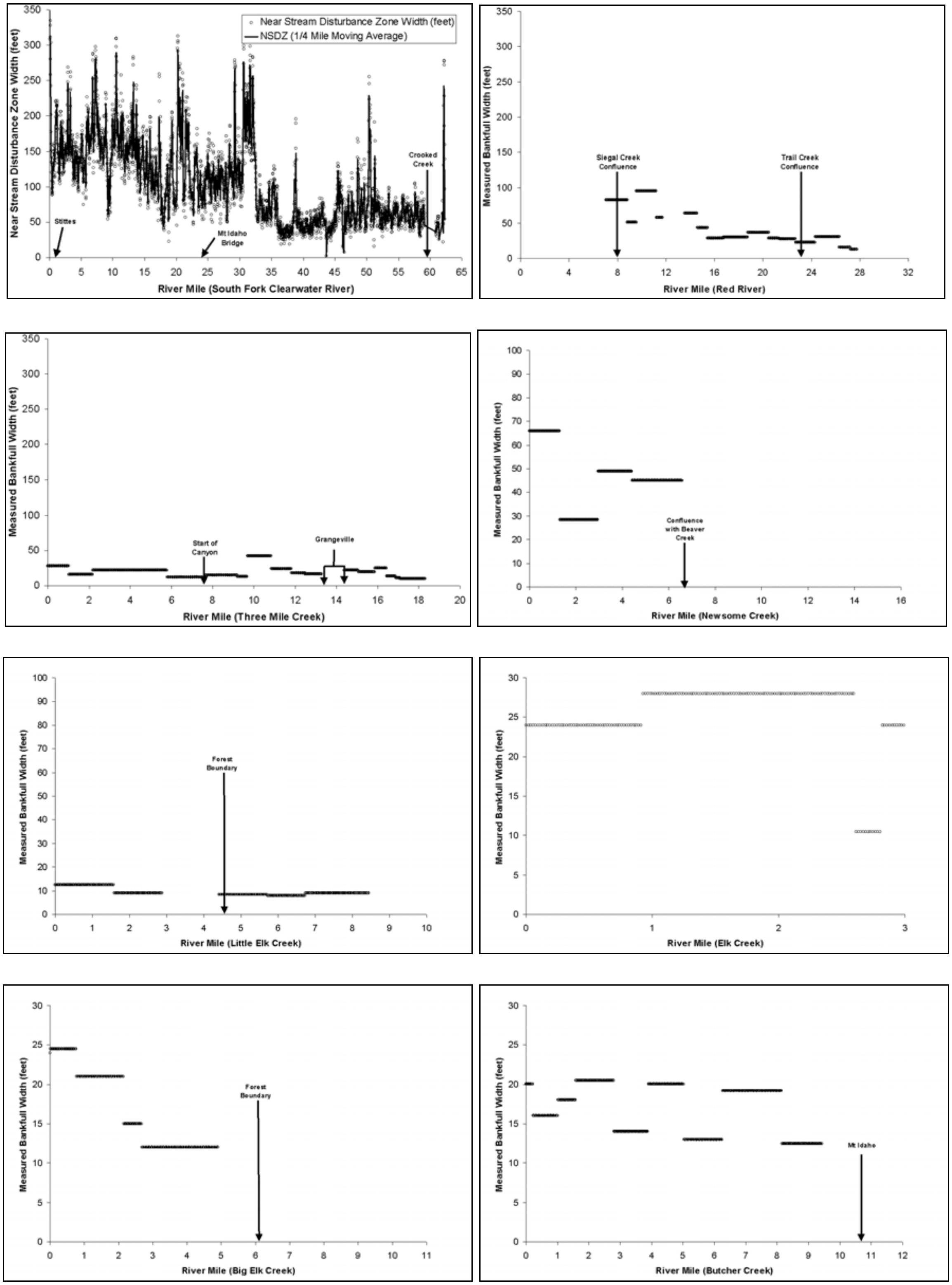


Figure F-10. Calculated Near-Stream Disturbance Zone (NSDZ) Width and Measured Bankfull Width Data

Calculated Current Effective Shade Levels

Near-stream land cover information sampled from the Pi_stratum data set (see Figure F-6) was used to calculate current effective shade levels in 303(d) listed streams in the South Fork Clearwater River subbasin, and Red River. Specifically, effective shade was calculated for each 100-foot model node, taking into account: 1) stream elevation (see Figure F-8), 2) stream aspect (see Figure F-7), 3) topographic shade angle (see Figure F-9), and 4) NSDZ or bankfull width (see Figure F-10).

In addition, the stream location on the earth's surface was calculated in GIS, and the sun's position (i.e., solar altitude and solar azimuth) and movement through the sky were calculated for August 3, 2000. This day corresponds with the FLIR data collection and with the period of the year with maximum river temperatures (Figure F-11).

Calculated current effective shade levels for 303(d) listed streams and Red River are presented in Figure F-12. Current effective shade conditions could only be calculated for areas with an assigned bankfull width or NSDZ (see Figure F-10).

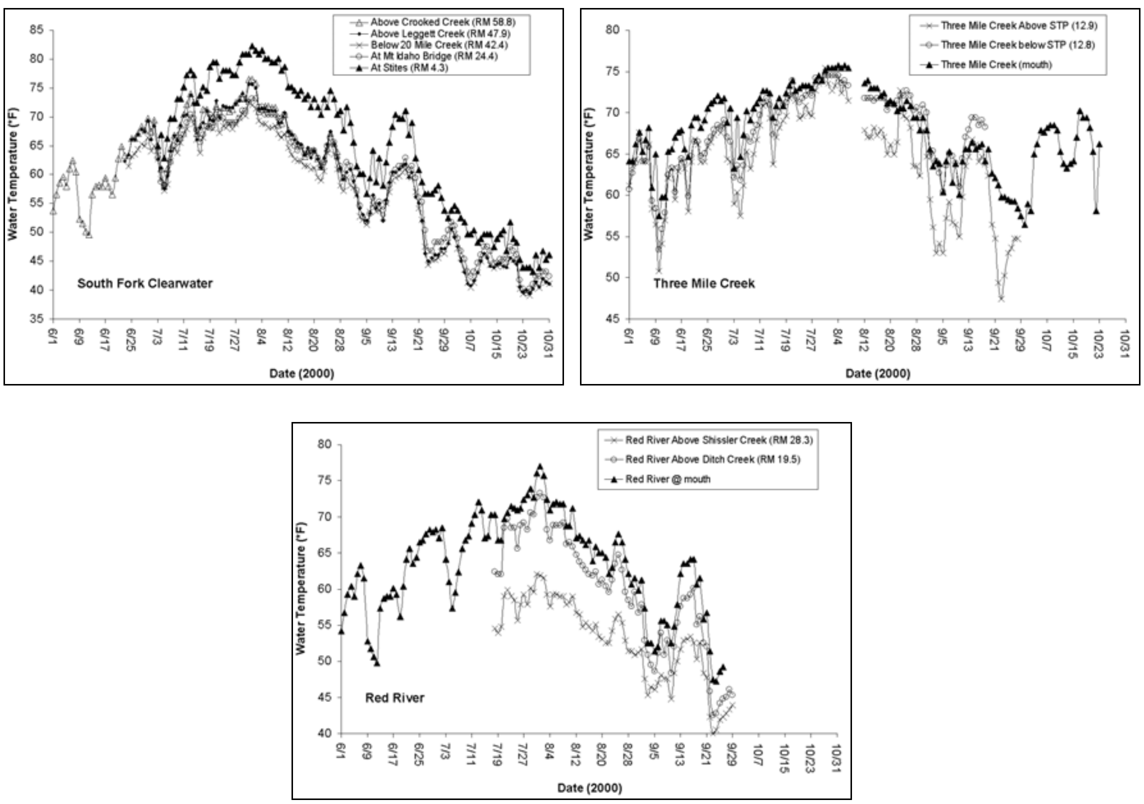


Figure F-11. Seasonal Variations in Temperature (Daily Maximum) in the South Fork Clearwater River, Threemile Creek, and Red River in the Summer of 2000

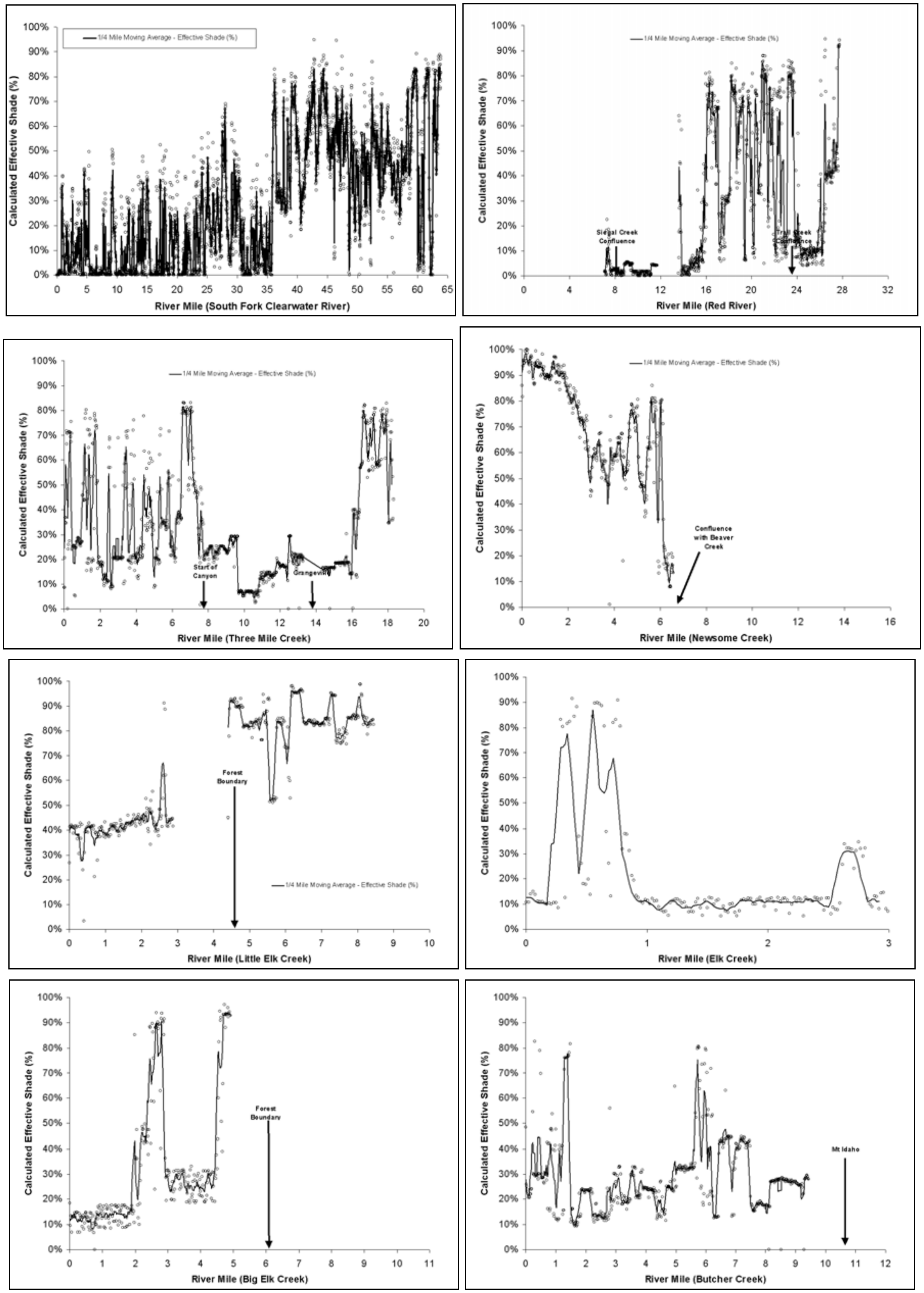


Figure F-12. Calculated Current Effective Shade for 303(d) listed streams and Red River

Current Effective Shade and Stream Temperature

When compared with effective shade levels, measured temperatures within the South Fork Clearwater River Subbasin (Figure F-13), illustrate that energy loading from solar radiation is a dominant factor causing elevated stream temperature in the lower reaches of this river system. In addition, the consequences of cumulative effects of frequent, but spatially minor, low shade areas are clearly presented within the lower Clearwater River (downstream of approximately river mile 24.4), resulting in great temperature increases (the cumulative effects principle is described in Appendix I). Temperatures are already relatively elevated at the beginning of the main stem South Fork Clearwater River, which is the confluence of Red and American River systems. These elevated temperatures reduce slightly as the river travels through the forested areas of the NPNF. The diurnal temperature pattern within this upper reach is maintained throughout the reach, but the diurnal variation increases dramatically in the lower sections of the river (Figure F-13). This downstream area corresponds with periodically low effective shade conditions.

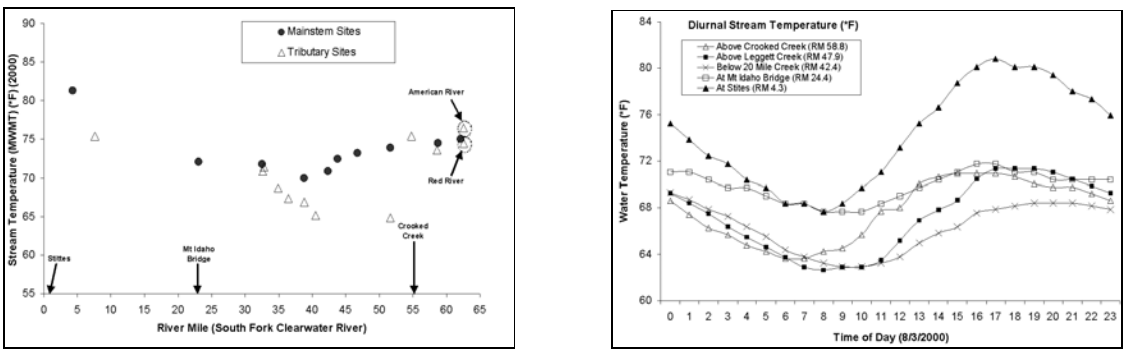


Figure F-13. SF Clearwater River Main Stem – Calculated Maximum Weekly Maximum Temperatures in 2000 and Observed Diurnal Temperatures on August 3, 2000

As mentioned above, stream temperatures are elevated in the South Fork Clearwater River at the confluence of the Red and American Rivers. Elevated stream temperatures in the Red River illustrate a similar pattern of stream temperature increase within areas of infrequent, low effective shade conditions (Figure F-14). These elevated temperatures developed in the Red River (along with the other headwater streams) affect temperature conditions for many miles downstream in the South Fork Clearwater (Figure F-13).

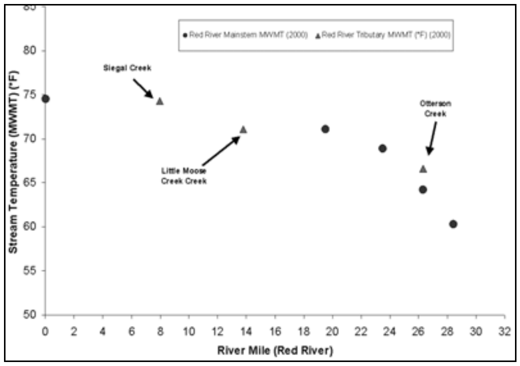


Figure F-14. Maximum Weekly Maximum Temperatures Measured along the Red River in 2000

Stream Side Activities Influencing Riparian and Stream Side Processes

Areas where current and/or historic stream side activities influence riparian and stream side processes are presented within the NPNF *South Fork Clearwater River Landscape Assessment* (USDA 1998). Stream side activities were separated into three categories within this analysis: 1) historic mining activities near the stream, 2) road encroachment on stream channels, and 3) current or historic grazing effects on stream or riparian processes (Figure F-15). These disturbance processes can have a tremendous effect on the parameters that influence temperature conditions within these rivers. For example, Figure F-16 illustrates that road encroachment along the South Fork Clearwater River Subbasin can result in great reduction of localized stream surface shade conditions in the river.

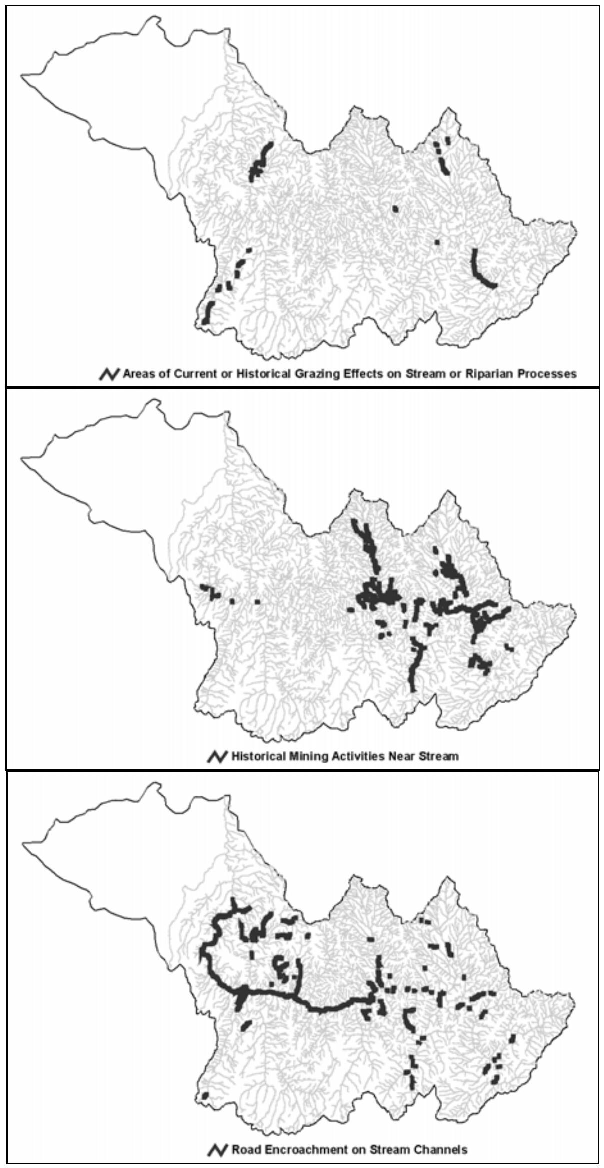


Figure F-15. Stream Side Activities Influencing Riparian and Stream Side Processes in the South Fork Clearwater River Subbasin

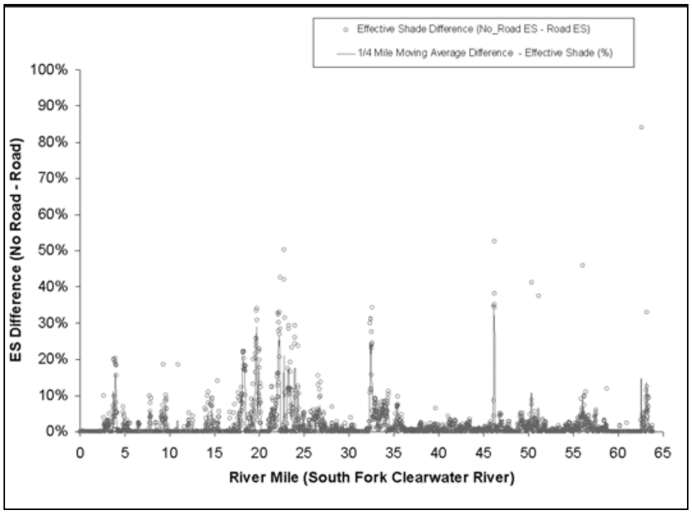


Figure F-16. Calculated Effective Shade (ES) Reduction Resulting from Road Encroachment (Measured as Percent Shade)

System Potential Vegetation TMDL Components

Temperature Nonpoint Sources – Clean Water Act §303(d)(1)

Riparian vegetation, stream morphology, hydrology, climate, and geographic location all influence stream temperature. While climate and geographic location are outside of human control, riparian condition, channel morphology, and hydrology are affected by land use activities. Human activities that can degrade thermal water quality conditions in the South Fork Clearwater River Subbasin watersheds are associated with agriculture, forestry, roads, urban development, and rural residential related riparian disturbance. Specifically, the elevated summertime stream temperatures attributed to anthropogenic nonpoint sources result from the first two items discussed below. Non-anthropogenic sources are also discussed.

Near-Stream Vegetation Disturbance and Removal

This reduces stream surface shading via decreased riparian vegetation height, width, and/or density, thus increasing the amount of solar radiation reaching the stream surface (shade is commonly measured as percent effective shade or percent open sky). Riparian vegetation also plays an important role in shaping the channel morphology, resisting erosive high flows, and maintaining floodplain roughness.

Channel Modifications and Widening (Increased Width to Depth Ratios)

Channel modifications and widening increase the stream surface area exposed to energy processes, namely solar radiation. Bankfull width or NSDZ widening decreases the potential shading effectiveness of shade-producing near-stream vegetation.

Natural Sources and Stream Temperature Natural Conditions

Natural conditions that may impact riparian vegetation and result in elevated stream temperatures include drought, fires, insect damage to riparian vegetation, diseased riparian vegetation, and wind throw and blow down in riparian areas. The processes through which natural conditions affect stream temperatures include increased stream surface exposure to solar radiation and decreased summertime flows.

It was reported within the *South Fork Clearwater River Landscape Assessment* (USDA 1998) that:

> "Pre-settlement disturbances like fire affected the pattern of vegetation because fires tended to vary in size, frequency, severity, and distribution; both randomly and in response to terrain and conditions before the fire. This pervasive disturbance produced both some predictable patterns and great heterogeneity. Fire suppression has reduced this heterogeneity. Timber harvest has created some age class diversity, but not to the degree that fire did. Further, the uniformity of harvest treatments and harvest unit size has resulted in less diversity at the landscape and stand level."

This document goes on to make the following conclusions:

> "Historical sediment delivery and water yield were highly dependent on natural fire regimes. Current sediment delivery and water yield are more closely aligned with disturbances associated with road construction, timber harvest, mining, and grazing." (USDA 1998, p.)
>
> "Timber harvest has replaced fire as the dominant vegetation disturbance process, but this harvest has not sustained landscape pattern; specifically for elements like large pine, larch, and snags. Susceptibility to certain pathogens (root rots and spruce budworm) has increased with increases in grand fir and subalpine fir." (USDA 1998, p.)
>
> "Predominantly pulse disturbances of fire and flood have been supplanted by wide scale press disturbances of harvest and road-related sediment regimes that have impacted aquatic integrity." (USDA 1998, p.)

Loading Capacity – 40 CFR 130.2(f)

The loading capacity provides a reference for calculating the amount of pollutant reduction needed to bring water into compliance with standards. The U.S. Environmental Protection Agency's (USEPA)'s current regulation defines loading capacity as "the greatest amount of loading that a water can receive without violating water quality standards." (40 CFR § 130.2(f)).

The approach used to calculate the temperature loading capacity for this portion of the South Fork Clearwater River Subbasin TMDL is "system potential." System potential is achieved when nonpoint source solar radiation loading is representative of near stream vegetation and channel morphology conditions without human disturbance and point source discharges cause no measurable temperature increases in surface waters.

System Potential Effective Shade - Defined

The primary factors that affect shade are near-stream vegetation height and channel width (i.e., bankfull width). The maximum level of shade practical at a particular site is termed the “system potential” effective shade level. System potential effective shade occurs when:

1. Near-stream vegetation is at a mature life stage
   - Vegetation community is mature and undisturbed from anthropogenic sources
   - Vegetation height and density are at or near the potential expected for the given plant community
   - Vegetation is sufficiently wide to maximize solar attenuation
   - Vegetation width accommodates channel migrations

2. Channel width reflects a suitable range for hydrologic process given that near-stream vegetation is at a mature life stage
   - Stream banks reflect appropriate ranges of stability via vegetation rooting strength and floodplain roughness
   - Sedimentation reflects appropriate levels of sediment input and transport
   - Substrate is appropriate to channel type
   - Local high flow shear velocities are within appropriate ranges based on watershed hydrology and climate

System Potential Land Cover

As listed above, “system potential land cover” is necessary to achieve “system potential effective shade” and is defined for purposes of the TMDL as “the potential near-stream land cover condition which can grow and reproduce on a site, given climate, elevation, soil properties, plant biology, and hydrologic processes.” System potential does not consider management or land use as limiting factors. In essence, system potential is the design condition used for TMDL analysis that meets the temperature standard by minimizing human related warming.

System potential is an estimate of the condition where anthropogenic activities that cause stream warming are minimized. System potential is not an estimate of pre-settlement conditions. Although it is helpful to consider historic land cover patterns, channel conditions, and hydrology, many areas have been altered to the point that the historic condition is no longer attainable given drastic changes in stream location and hydrology (channel armoring, wetland draining, urbanization, etc.).

System Potential Simulation

Loading capacity in the South Fork Clearwater River Subbasin is largely controlled by nonpoint source influences of heat to the system. Temperatures rise throughout much of the watershed due to accumulated heat energy. The greatest change in the heat budget has been an increase in direct solar radiation loading due to human-caused reductions in shade.

System potential was estimated as the August solar radiation levels that would reach the stream surface under conditions where anthropogenic activities would not measurably increase temperature. The system potential radiation load is the loading capacity.

Current conditions were modeled using an effective shade calculator (Heat Source 6.5 [Boyd 1996]), using recently collected field data and other spatial data sources (i.e., bankfull width data, DEM, DOQ, and Pi_stratum). These features were measured on a very fine scale using existing GIS databases and by digitizing with digital orthophoto quadrats. Specifically, "system potential effective shade" was simulated by incorporating expected vegetation stand height and density conditions at "system potential land cover."

It is important to distinguish between site potential shade and system potential shade, the latter being a broad scale view. For a given location, it is expected that site potential shade could be greater than system potential shade. Over a large area (e.g., a river reach), it is unlikely that all sites will be at their site potential due to localized natural disturbances (e.g., fire, flood, landslide, disease, etc.) causing some fraction of the area to be in a less than "mature" state. Accordingly, "system potential land cover" used to calculate "system potential effective shade" incorporates a disturbance component that was developed from available land cover data sets.

Land Cover Classification

Vegetation Response Units (VRUs), Habitat Type Groups (HTGs), and the National Wetland Inventory (NWI) are three land cover classifications available for the South Fork Clearwater River Subbasin. Land cover classifications from these sources are spatially explicit and are mapped out for the basin.

The VRUs and HTGs emphasize the vegetation component of land cover and differentiate between forest and non-forest land cover types. These were used, along with NWI data, to establish the vegetative community descriptions used in to develop appropriate shade targets for the South Fork Clearwater River Subbasin. Brief descriptions of VRUs, HTGs, and the NWI are presented below, and detailed information about VRU and HTG is presented in Appendix H**.**

Vegetation Response Units

The VRUs are broad ecological land units that display unique patterns of habitat type groups (potential vegetation) and terrain. The VRU classification and delineation was developed for the South Fork Clearwater River Subbasin and was reported within the *South Fork Clearwater River Landscape Assessment* (USDA 1998) (Figure F-17). The components used to build the VRU classification system are habitat type groups (potential vegetation), landform, and pre-settlement disturbance processes (like fire regimes). The VRUs are basically a product of geology, landform, climate, and soil. Individual VRUs have similar patterns of disturbance and successional processes. Patterns of plant community composition, age class structure, and patch size will tend to fall within certain ranges for each VRU. The VRUs are intended to provide a means to estimate resource capabilities, ecological integrity, and responses to natural and human-caused disturbances. Ultimately, VRUs are intended to be templates for assessing historic and current condition and developing target or desired landscapes.

Table F-5 illustrates the percent distribution of VRU classes within a 300-meter buffer surrounding the South Fork Clearwater River and several major tributaries. As can be seen in this table, riparian areas are often dominated by a few VRU classes, and the total number of VRU classes for each river system is limited. A detailed description of the 13 individual VRU habitat types within the South Fork Clearwater River Subbasin are provided in Appendix H.

Table F-5. Percent distribution of Vegetation Response Units (VRUs) within a 300-meter buffer surround the South Fork Clearwater River and several major tributaries.

VRU #	SF CWR	Three-mile Creek	Crooked Creek	Red River	American River	Little Elk Creek	Big Elk/Elk Creek	Newsome Creek
1	- -	- -	20.4	1.5	- -	- -	3.0	0.3
2	- -	- -	5.4	- -	- -	- -	- -	- -
3	88.0	39.0	50.9	2.1	- -	- -	1.4	21.8
4	- -	- -	- -	12.7	- -	- -	- -	- -
5	- -	- -	- -	- -	- -	- -	- -	- -
6	6.8	- -	13.2	83.7	79.7	54.7	69.8	29.8
7	0.4	- -	10.1	- -	6.0	37.8	14.0	41.1
8	- -	- -	- -	- -	- -	- -	- -	- -
9	- -	- -	- -	- -	- -	0.2	0.3	- -
10	- -	- -	- -	- -	14.3	7.2	11.5	7.1
12	4.4	8.7	- -	- -	- -	- -	- -	- -
16	- -	52.3	- -	- -	- -	- -	- -	- -
17								
98	0.4	- -	- -	0.0	0.1	- -	0.0	- -

(VRU #98 signifies "no code")

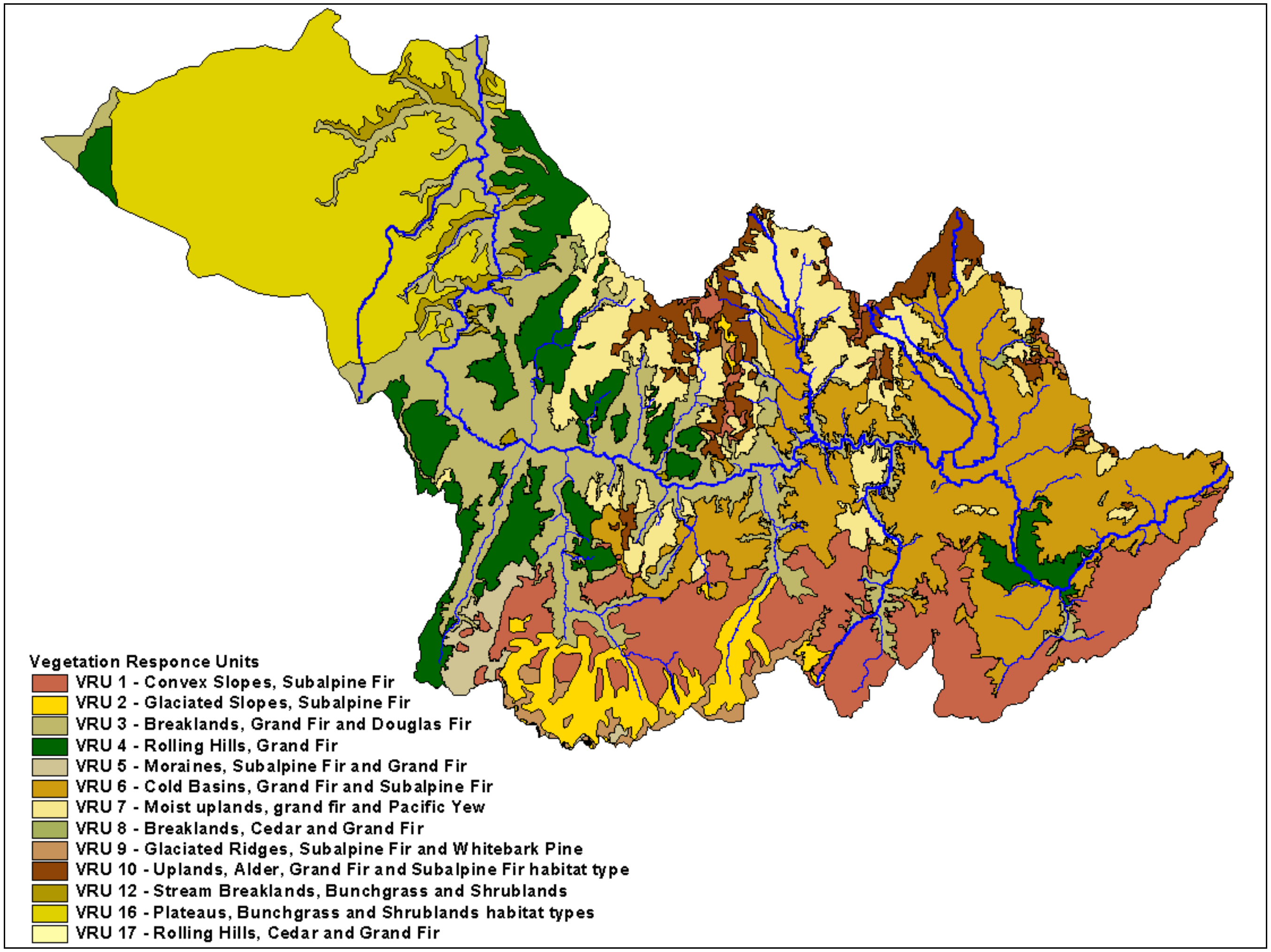


Figure F-17. Vegetation Response Units (VRUs) for the South Fork Clearwater River Subbasin

Forested Vegetation Response Units – Vegetation communities listed for each “forested” VRU are presented in Table F-6. Vegetation is separated into dominant vegetation and “other overstory” vegetation. The relative proportion of vegetation size class composition for each “forested” VRU is summarized in Table F-7.

Table F-6. Vegetation composition within “forested” Vegetation Response Units (VRUs).

VRU #		Dominant Vegetation*	Other Overstory*
1	Convex slopes, subalpine fir	GF, SAF, LP	ES, WL, DF, WBP
2	Glaciated slopes, subalpine fir	SAF, LP, ES	
3 - South	Breaklands, grand fir and Douglas fir	DF, PP	
3 - North	Breaklands, grand fir and Douglas fir	GF, DF	PP, WL, ES, LP
4	Rolling hills, grand fir	GF, DF, PP, WL	LP, ES
5	Moraines, subalpine fir and grand fir	LP, ES	GF, DF, SAF, WL
6	Cold basins, grand fir and subalpine fir	LP, WL, DF, ES, GF	WBP
7	Moist uplands, grand fir and Pacific yew	GF, DF, PY	WL, ES, LP
8	Breaklands, cedar and grand fir	GF, DF	WL, WRC, WWP, ES, PY, PP, LP
9	Glaciated ridges, subalpine fir and whitebark pine	WBP, SAF, ES, LP	
10	Uplands, alder, grand fir and subalpine fir	GF, SAF, ES, Sitka, Alder	
17	Rolling hills, cedar and grand fir	GF, DF	WRC, WWP, WL, ES, PP

*GF, Grand Fir; SAF, Subalpine Fir; LP, Lodgepole Pine; ES, Engelmann Spruce; WL, Western Larch; DF, Douglas Fir; WBP, Whitebark Pine; PP, Ponderosa Pine; PY, Pacific Yew; WRC, Western Red Cedar; WWP, Western White Pine

Table F-7. Relative proportion (percentage) of vegetation size classes for Vegetation Response Units (VRUs).

VRU #	Non-Forest (non-stock)	Seedling/ Sapling	Pole	Medium Tree	Large Tree
1	5-10	20-30	20-30	20-30	5-15
2	10-25	10-30	30-65	5-15	10-10
3-South	5-20	5-30	10-20	20-40	20-40
3-North	5-20	5-30	10-20	20-40	20-40
4	5-10	5-50	10-30	20-30	10-50
5	5	10-40	20-60	5-30	3-10
6	5-10	10-30	30-45	20-40	5-20
7	1-10	5-20	10-25	25-35	35-45
8	5-20	5-30	10-20	30-50	20-30
9	30-40	10-30	15-60	1-10	1
10	10-25	15-25	20-30	25-40	15-25
17	10-25	15-25	20-30	20-35	15-40

<u>**Non–Forested Vegetation Response Units**</u> –Two VRUs within the South Fork Clearwater River Subbasin are dominated by non-forest vegetation. Vegetation Response Units 12 and 16 are located primarily within the low elevation areas of the subbasin (see image to right). Detailed descriptions about these VRUs are presented below (USDA 1998).

VRU 12: Stream breaklands, bunchgrass, and shrublands – This VRU is rare on NPNF lands in the subbasin, but is common in the lower canyon on private lands. Bluebunch wheatgrass and Idaho fescue habitat types are dominant. Shrubland habitat types are common. Bluebunch wheatgrass and Idaho fescue were historically important. Shrublands occupied draws or lower slopes. Very frequent (5-25 years), low severity fires maintained open grasslands and rejuvenated shrublands.

***VRU 12: Changes from historic conditions* -** On all lands, only general trends have been noted. Disturbed grasslands (annuals and weeds) and pasture have replaced native perennials over more than 50% of their prior extent. Upland shrublands have increased as much as 100% due to fire suppression and brush invasions of former grasslands. About 2 acres have burned annually on NPNF lands in the subbasin since fire suppression became effective, a decline of about 82%.

VRU 16: Plateaus, bunchgrass, and shrubland – This VRU occurs only on non-NPNF lands. Bluebunch wheatgrass, Idaho fescue, and shrubland habitat types are common. Bluebunch wheatgrass and Idaho fescue were historically important. Shrublands occupied draws, lower slopes, and north aspects. Very frequent (5-25 years), low severity fires maintained open grasslands and rejuvenated shrublands.

VRU 16: Changes from historic conditions – On all lands, only general trends have been noted. Annual cropland has replaced native perennials on more than 80% of their prior extent. Hayland and pasture have largely replaced the remaining native prairie. Upland shrublands have probably also decreased. Fire incidence has certainly declined, but to what extent is unknown.

Habitat Type Groups

Habitat type grouping is based on similarities in natural disturbance regimes, successional patterns, and structural characteristics of mature stands. The HTGs are intended to assist with sub-regional and landscape assessments. Habitat Type Groups were developed for northern Idaho and western Montana. Classified HTGs within the South Fork Clearwater River Subbasin were subsequently adapted from the original HTG coverage (Figure F-18). The HTGs are separated into forest and non-Forest categories. A detailed description for each category is presented in Appendix H. The HTG information was obtained from the document, *Biophysical Classification – Habitat Groups and Descriptions*.

Vegetation Response Units and Habitat Type Groups

Extensive GIS sampling was conducted on both the VRU and HTG coverages in order to determine the distribution of HTGs for each VRU within a 300-meter buffer surrounding the South Fork Clearwater River and several major tributaries. Table F-8 presents the measured distribution for these parameters.

The HTG coverage is at a higher spatial resolution of vegetation land conditions than the VRU. Accordingly, several HTGs are often observed for each VRU. However, there is a very close relationship between land cover conditions described within these two data sets.

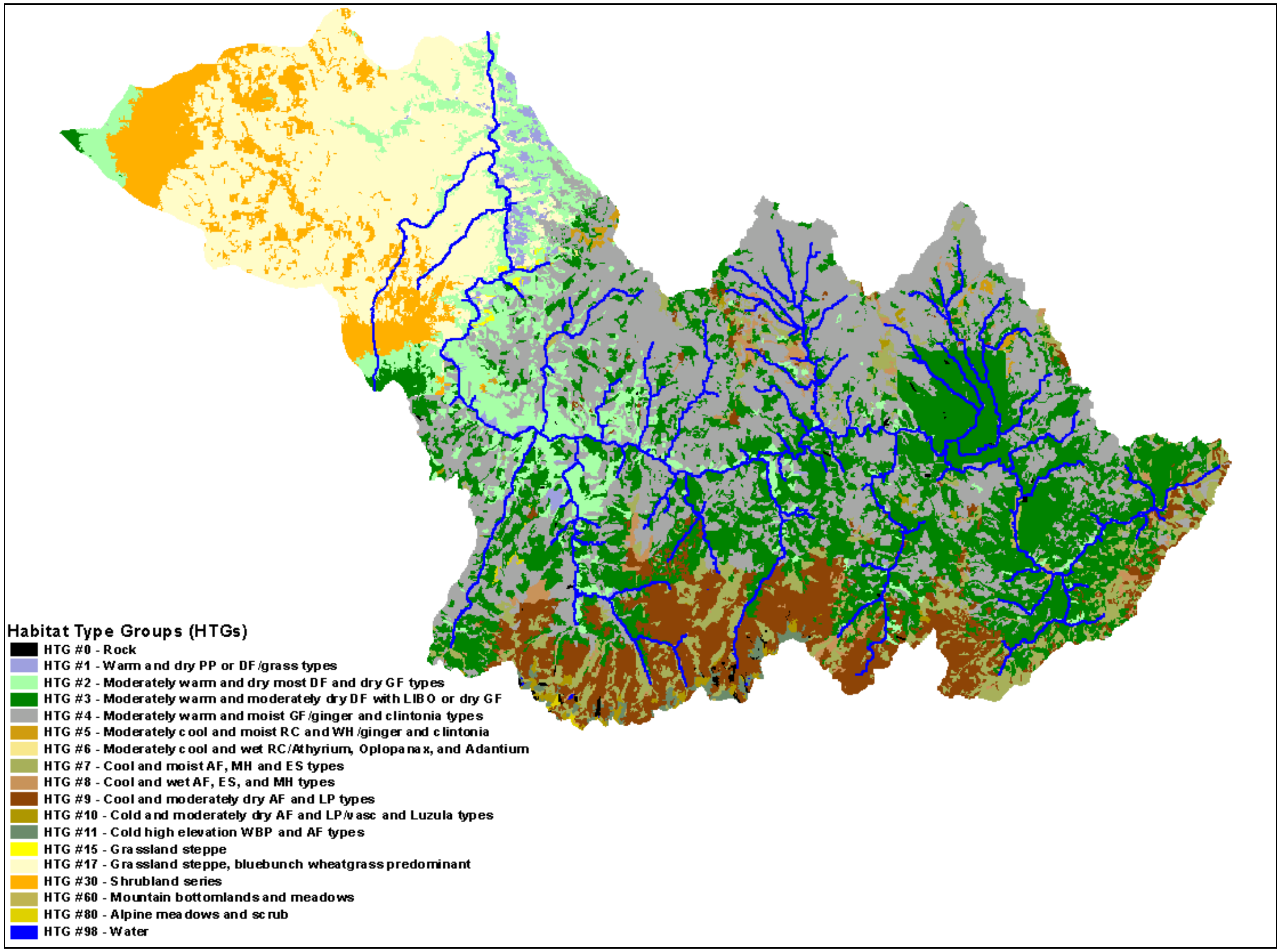


Figure F-18. Habitat Type Groups Within the South Fork Clearwater River Subbasin

Table F-8. Percent distribution of Habitat Type Groups (HTGs) for each classified Vegetation Response Units (VRUs) zone within a 300-meter buffer surrounding the South Fork Clearwater River and several major tributaries.

Main Stem South Fork Clearwater River

HTG (VRU 3)	% of Total	HTG (VRU 6)	% of Total	HTG (VRU 7)	% of Total	HTG (VRU 12)	% of Total	HTG (VRU 99)	% of Total
0	1.0%	0	0.0%			0	0.0%	0	0.2%
1	5.4%					1	0.6%	1	0.0%
2	35.6%	2	0.2%	2	0.0%	2	1.2%	2	0.1%
3	14.5%	3	4.6%	3	0.2%				
4	18.0%	4	2.0%	4	0.3%	4	0.0%	4	0.0%
7	0.2%								
15	0.1%					15	0.4%	15	0.0%
17	12.1%					17	2.2%	17	0.0%
30	0.0%								
50	1.2%					50	0.0%	50	0.0%
98	0.0%							98	0.0%
Total	**88.0%**	**Total**	**6.8%**	**Total**	**0.4%**	**Total**	**4.4%**	**Total**	**0.4%**

Threemile Creek

HTG (VRU 3)	% of Total	HTG (VRU 12)	% of Total	HTG (VRU 16)	% of Total
1	0.2%			1	0.2%
2	15.1%	2	4.1%	2	0.7%
3	3.6%				
17	17.4%	17	4.5%	17	30.3%
30	1.2%	30	0.1%	30	21.1%
50	1.4%			50	0.0%
Total	**39.0%**	**Total**	**8.7%**	**Total**	**52.3%**

Red River

HTG (VRU 1)	% of Total	HTG (VRU 3)	% of Total	HTG (VRU 4)	% of Total	HTG (VRU 6)	% of Total	HTG (VRU 99)	% of Total
				0	0.1%	0	0.5%		
						1	0.0%		
2	0.0%	2	1.1%	2	2.7%	2	2.4%		
3	0.1%	3	0.7%	3	8.7%	3	39.0%		
		4	0.3%	4	0.7%	4	9.9%		
7	1.2%			7	0.3%	7	6.7%		
8	0.1%					8	3.8%		
9	0.1%					9	4.3%		
				60	0.2%	60	17.1%	60	0.0%
Total	**1.5%**	**Total**	**2.1%**	**Total**	**12.7%**	**Total**	**83.7%**	**Total**	**0.0%**

Big Elk Creek

HTG (VRU 1)	% of Total	HTG (VRU 3)	% of Total	HTG (VRU 6)	% of Total	HTG (VRU 7)	% of Total	HTG (VRU 9)	% of Total	HTG (VRU 10)	% of Total	HTG (VRU 99)	% of Total
3	0.0%			3	53.2%	3	1.1%	3	0.3%	3	0.2%	3	0.0%
		4	1.2%	4	16.5%	4	7.7%	4	0.0%	4	6.5%		
7	1.3%	7	0.1%	7	0.1%	7	2.1%			7	2.5%		
8	0.8%					8	3.2%	8	0.0%	8	2.4%		
9	0.9%							9	0.0%	9	0.0%		
Total	3.0%	Total	1.4%	Total	69.8%	Total	14.0%	Total	0.3%	Total	11.5%	Total	0.0%

Table F-8 (continued). Percent distribution of Habitat Type Groups (HTGs) for each classified Vegetation Response Units (VRUs) zone within a 300-meter buffer surrounding the South Fork Clearwater River and several major tributaries.

American River

HTG (VRU 6)	% of Total	HTG (VRU 7)	% of Total	HTG (VRU 10)	% of Total	HTG (VRU 99)	% of Total
0	0.4%						
2	0.1%						
3	59.9%	3	1.5%	3	1.8%	3	0.1%
4	14.3%	4	4.1%	4	10.0%		
7	0.3%			7	2.4%		
8	1.1%	8	0.4%	8	0.1%		
9	1.2%						
60	2.3%						
Total	**79.7%**	**Total**	**6.0%**	**Total**	**14.3%**	**Total**	**0.1%**

Little Elk Creek

HTG (VRU 6)	% of Total	HTG (VRU 7)	% of Total	HTG (VRU 10)	% of Total	HTG (VRU 99)	% of Total
0	0.4%						
2	0.1%						
3	59.9%	3	1.5%	3	1.8%	3	0.1%
4	14.3%	4	4.1%	4	10.0%		
7	0.3%			7	2.4%		
8	1.1%	8	0.4%	8	0.1%		
9	1.2%						
60	2.3%						
Total	**79.7%**	**Total**	**6.0%**	**Total**	**14.3%**	**Total**	**0.1%**

Crooked Creek

HTG (VRU 1)	% of Total	HTG (VRU 2)	% of Total	HTG (VRU 3)	% of Total	HTG (VRU 6)	% of Total	HTG (VRU 7)	% of Total
0	0.0%			0	0.4%				
				1	0.2%				
2	1.2%	2	0.2%	2	7.5%	2	0.2%	2	0.1%
3	9.3%	3	0.6%	3	26.7%	3	8.1%	3	3.8%
4	0.9%	4	0.2%	4	12.5%	4	3.6%	4	5.2%
7	1.8%	7	0.9%	7	1.3%	7	0.3%	7	0.7%
8	4.1%	8	2.4%						
9	3.0%	9	1.1%	9	2.2%	9	1.0%	9	0.3%
Total	**20.4%**	**Total**	**5.4%**	**Total**	**50.9%**	**Total**	**13.2%**	**Total**	**10.1%**

Newsome Creek

HTG (VRU 1)	% of Total	HTG (VRU 3)	% of Total	HTG (VRU 6)	% of Total	HTG (VRU 7)	% of Total	HTG (VRU 10)	% of Total
		0	0.0%						
		2	3.2%						
		3	2.1%	3	8.0%	3	11.2%		
4	0.3%	4	10.3%	4	13.2%	4	29.8%	4	7.1%
		7	4.0%	7	2.7%	7	0.0%		
		8	1.9%	8	4.4%	8	0.0%		
		9	0.3%	9	0.2%				
				60	1.4%	60	0.0%		
Total	**0.3%**	**Total**	**21.8%**	**Total**	**29.8%**	**Total**	**41.1%**	**Total**	**7.1%**

National Wetlands Inventory

A wetland database has been developed for the South Fork Clearwater River Subbasin (Harrison and Kellogg 1987). The database, part of the National Wetlands Inventory (NWI), contains a description of riparian wetland locations throughout the subbasin. Wetlands are broken into three main categories: 1) herbaceous, 2) forested, and 3) shrub. These are subdivided into numerous other units based on site-specific information. Classifications were developed through an analysis of aerial photographs, examining visible vegetation, hydrology, and geography. Figure F-19 illustrates the spatial distribution of wetland areas within the South Fork Clearwater River Subbasin.

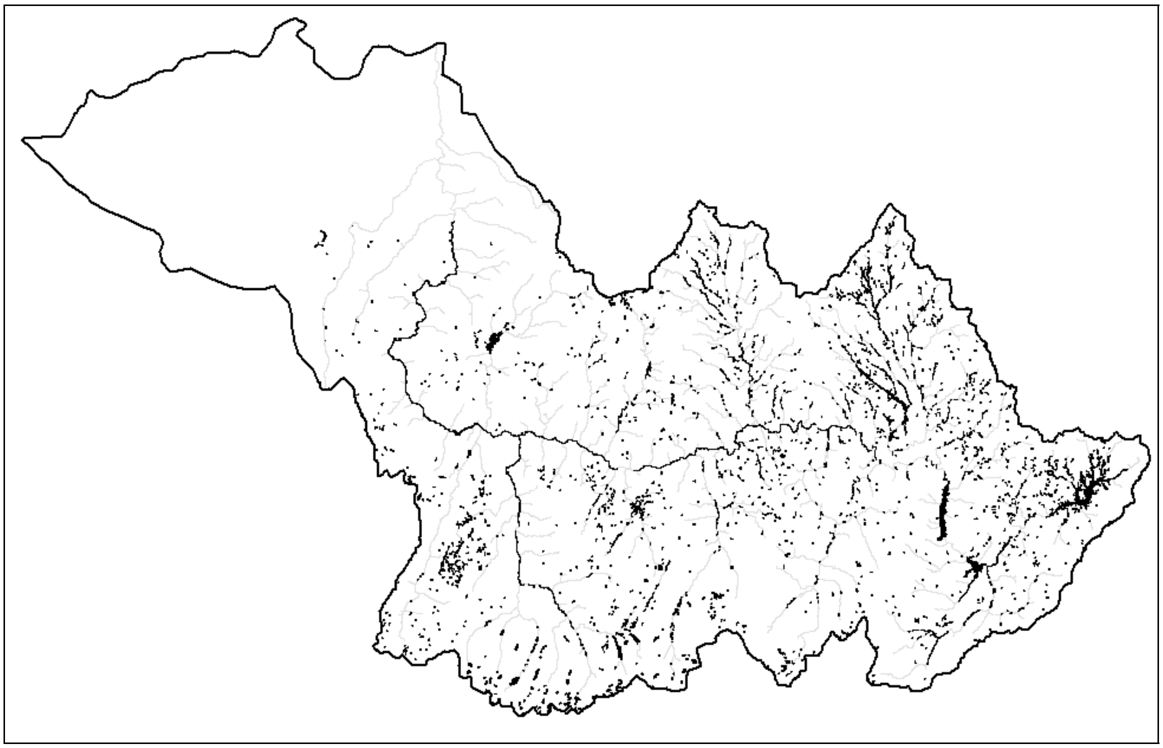


Figure F-19. National Wetlands Inventory for the South Fork Clearwater River Subbasin

It was estimated from this work that only 4-6% of the land area within NPNF meets the Forest Service riparian area definition for a riparian wetland. The purpose of this inventory was to map out riparian wetland areas so that those areas could be protected, and thus provide benefits to the public through flood and storm damage control, erosion control, water quality improvement, and fish and wildlife resource protection.

System Potential Land Cover Condition - "Forest" Vegetation

Mature vegetation height information for species present within the South Fork Clearwater River Subbasin is listed in Table F-9. Note that the upper end of measured tree heights within the South Fork Clearwater River Subbasin (illustrated in Figure F-4 and presented in Table F-2) correspond closely with the values reported below.

Table F-9. Mature vegetation height condition (U.S. Department of Agriculture Fire Effects Information System [fs.fed.us/database/feis])

Vegetation Type	Height (ft)	Average Value (ft)	High Elev (ft)	Mid - Low Elev (ft)
Grand fir	131 - 164	148	140	152
Engelmann spruce	45 - 130	88	65	110
Douglas fir	100 - 130	115		
Subalpine fir	60 - 100	80		
Ponderosa pine	90 - 130	110		
Lodgepole pine	60 - 80	70		
Western red cedar	70 - 100	85		
Western larch		164	130 (upper SW facing)	170 (lower NE facing)
Rocky mountain maple	20 - 30	25		
Western white pine		200		
Whitebark pine	50 - 70	60		
Sitka alder	10 - 15	12		
Pacific yew	20 - 40	30		
Black cottonwood		100		
Western hemlock	100 - 150	125	110	140
Red osier dogwood	3 - 19	11		
Thimbleberry	6.6 - 8.2	7.4		
Western snowberry	2 - 4	3		
Western serviceberry	3 - 26	15		
Booth willow	9 - 18	14		
Geyer willow	up to 20	15		
Drummond willow	6.5 - 13	10		
Carex rostrata	1 - 4	2.5		
Carex lenticularis	0.1 - 1	0.5		

As mentioned previously, it is unlikely that all sites throughout a watershed will be at a mature condition due to localize natural disturbances (e.g., fire, flood, landslide, disease, etc.). causing some fraction of the area to be in a less than “mature” state. Accordingly, the relative proportion of size classes established for each VRU was used to incorporate age structure for the estimate of height conditions, which was used to establish system potential effective shade conditions. That is, the riparian community is represented by various age classes. Those age classes will be used to calculate respective height conditions for these age classes. Size class information for each VRU is presented in Table F-7.

The following steps were used to estimate size class distribution for each VRU based on the reported ranges in Table F-7:

- Step 1 - Allocate maximum value for percent “large tree” class
- Step 2 - Allocate maximum value for percent “non-stock” class
- Step 3 - Allocate maximum, or remaining, value for percent “medium tree” class
- Step 4 - Allocate maximum, or remaining, value for percent “pole” class
- Step 5 - Allocate remaining value for percent “seedling/sapling” class

For example, VRU 4 would be allocated 50% for “large tree” (i.e., maximum value), 10% for “non-stocked” (i.e., maximum value), 30% for “medium tree” (i.e., maximum or remaining value), 10% for “pole” (i.e., maximum or remaining value), and 0% for “seedling/sapling” (i.e., remaining value). As can be seen, this method incorporates an estimate of expected open areas (“non-stock”), as well as incorporates disturbance through using the expected size classes.

The following rules were used to estimate height conditions for each of the size classes.

- “Large tree” was assigned the average of mature vegetation height (see Table F-9)
- “Medium tree” and “pole” were assigned a height calculated from species-specific growth curves developed from data collected within the NPNF (see Table F-3). The dbh values used in this calculation were assigned the maximum of the range listed for the size class (see Table F-1)
- “Seedling/sapling” was assigned a value of 20 feet
- “Non-stock” was assigned a height of zero

As noted in Table F-6, numerous vegetation species (categorized into “dominant” and “other overstory” groups)are shown to be present within each VRU category. Vegetation height conditions were developed for each species present within the respective VRU, which were summarized into a weighted average condition using values calculated using the size class distribution rule set presented above. These values for each species were average within “dominant,” and “other overstory” groups (see Table F-6). A weighting factor of 80% for dominant and 20% for “other overstory” was used (i.e., (75’ * 80% = 60’ (dominant)) plus (90 * 20% = 18 (other overstory)) = 78’).

Overhang was assigned a value of 10% of the final vegetation height (i.e., 78 feet * 10% = 7.8 feet). Overhang is the tree branch length from the trunk of the tree.

System Potential Land Cover Condition - "Non-Forest" Vegetation

Vegetation height, used to develop system potential effective shade, for "non-forest" areas, was calculated as the average of mature vegetation height. The percent of the stream bank not covered by any vegetation for "non-forest" areas is 10% for both shrub and wetland areas. This is analogous to the "non-stock" category in forested areas.

Shrub vegetation used to calculate vegetation height was obtained from HTG 30 (shrub steppe) (Appendix H). Based on shrub species in HTG 30, the average mature height was 8.4 feet. Grass was assigned a height of 1 foot. The distributions of shrub and grass were assigned 80% and 20%, respectively. Overhang was assigned 50% of height.

Riparian Wetlands

Approximately 4-6% of the land area within the NPNF is comprised of riparian wetlands (Figure F-20). Specifically, the NWI categorized wetland communities into scrub, herbaceous, and forest.

Herbaceous Meadow Wetland

A discussion of the best example of potential mature vegetation for a herbaceous meadow system in the South Fork Clearwater River Subbasin is included in the document, *Analysis of the Riparian Vegetation of Red River Meadows* (Brunsfeld 1994). The average of mature average vegetation heights of listed potential vegetation was 13.75 feet, and the average sedge height was 1.5 feet. The average of mature average vegetation heights of listed potential vegetation was used in calculating system potential conditions.

Forest Meadow Wetland

Bureau of Land Management staff provided site data from the East Fork of American River, (East Fork American River - Site # 3) which is a good example of a mature forest meadow wetland vegetation community within the South Fork Clearwater River Subbasin (Craig Johnson, BLM, personal communication). The distribution of vegetation measured at this site was 18% tree, 22% shrub, and 60% sedge. Tree vegetation at this site was 50% grand fir, 33% Engelmann spruce, and 17% lodgepole pine. Similar to "herbaceous meadow wetlands," the average of mature average vegetation heights of listed potential vegetation was used in calculating system potential conditions.

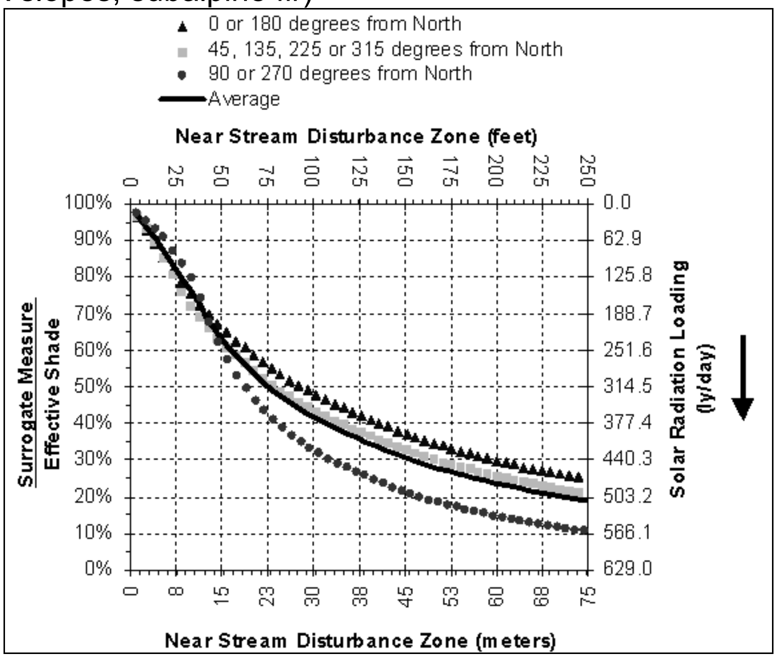
Scrub Meadow Wetland

Because of a lack of information, system potential land cover conditions used to develop system potential shade conditions for scrub meadow wetland systems were assigned values obtained from herbaceous meadow wetlands.

System Potential Effective Shade Calculation

System potential effective shade conditions were calculated using the estimated vegetation stand information presented above (Figure F-20). The Heat Source 6.5 shade calculator was used for this analysis (Boyd 1996).

VRU 1 (Convex slopes, subalpine fir)



VRU 2 (Glaciated slopes, subalpine fir)

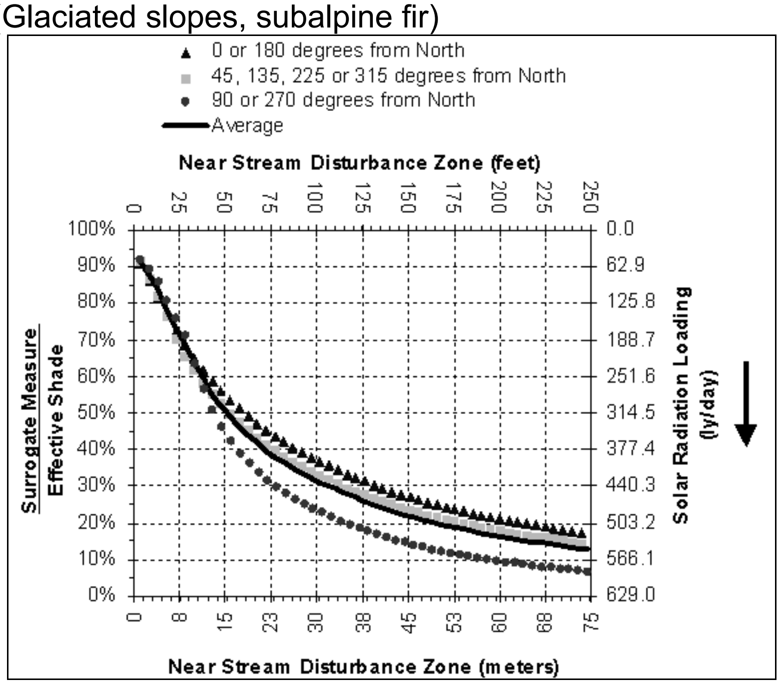
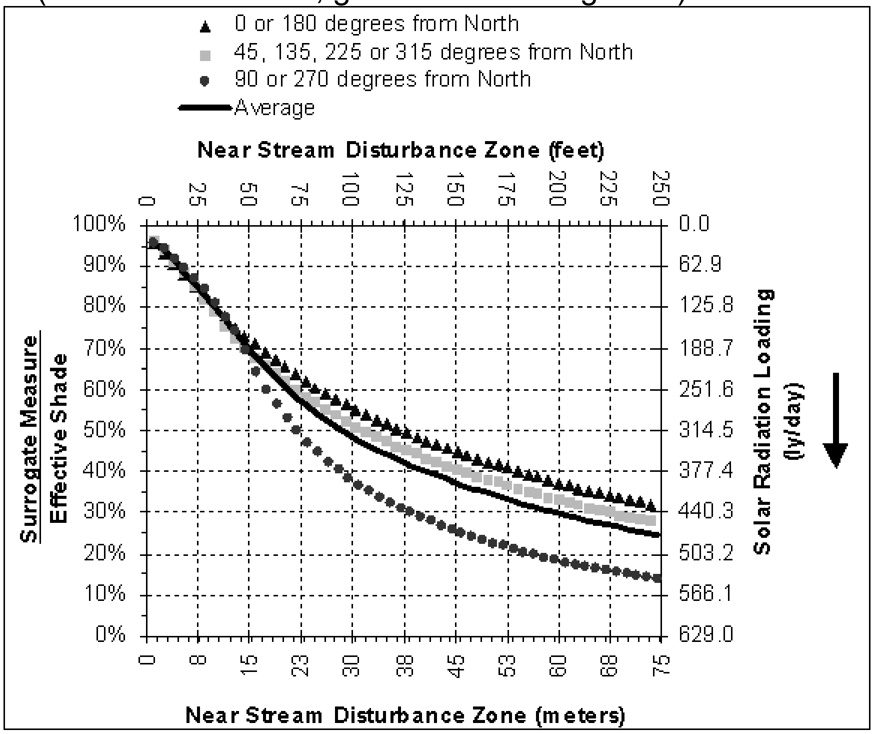


Figure F-20. Shade Curves Developed for Vegetation Response Units (VRUs)

VRU 3 (Stream breaklands, grand fir and Douglas-fir)



VRU 4 (Rolling hills, grand fir)

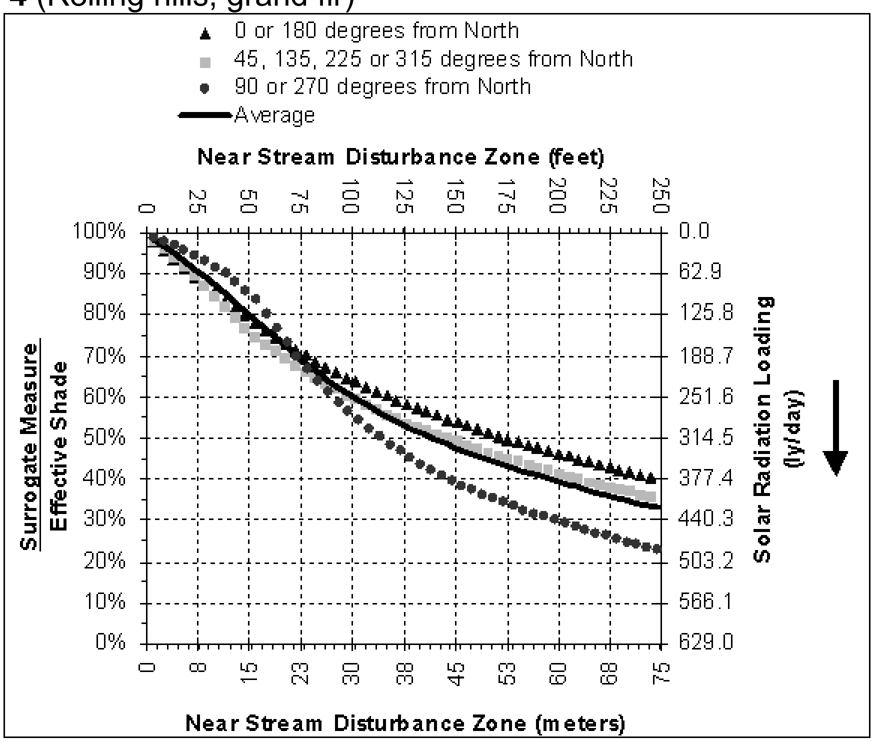
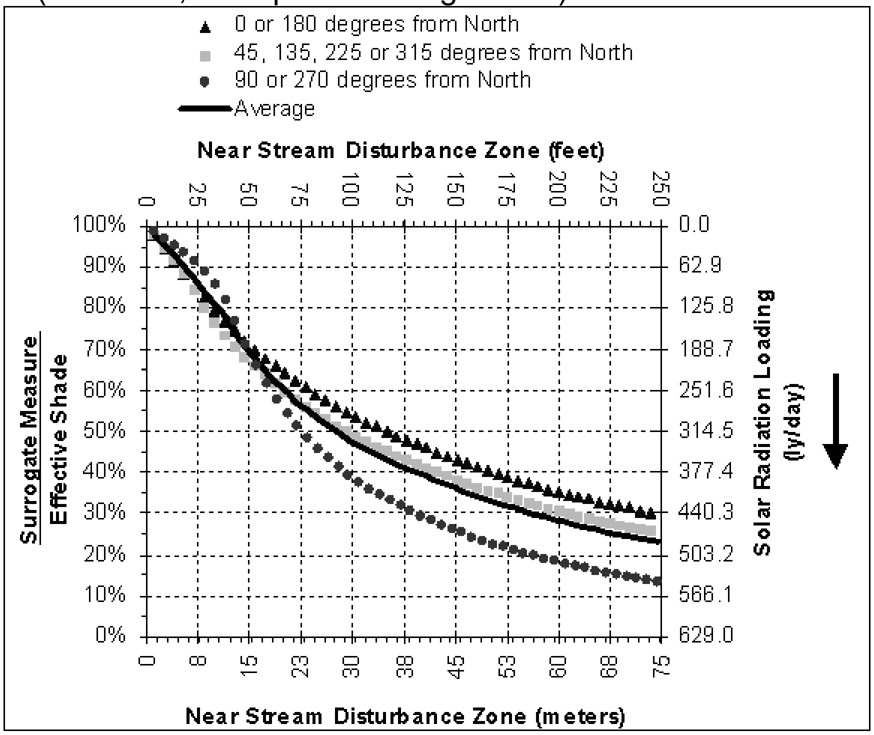


Figure F-20 (continued). Shade Curves Developed for Vegetation Response Units (VRUs)

VRU 5 (Moraines, subalpine fir and grand fir)



VRU 6 (Cold basins, grand fir and subalpine fir)

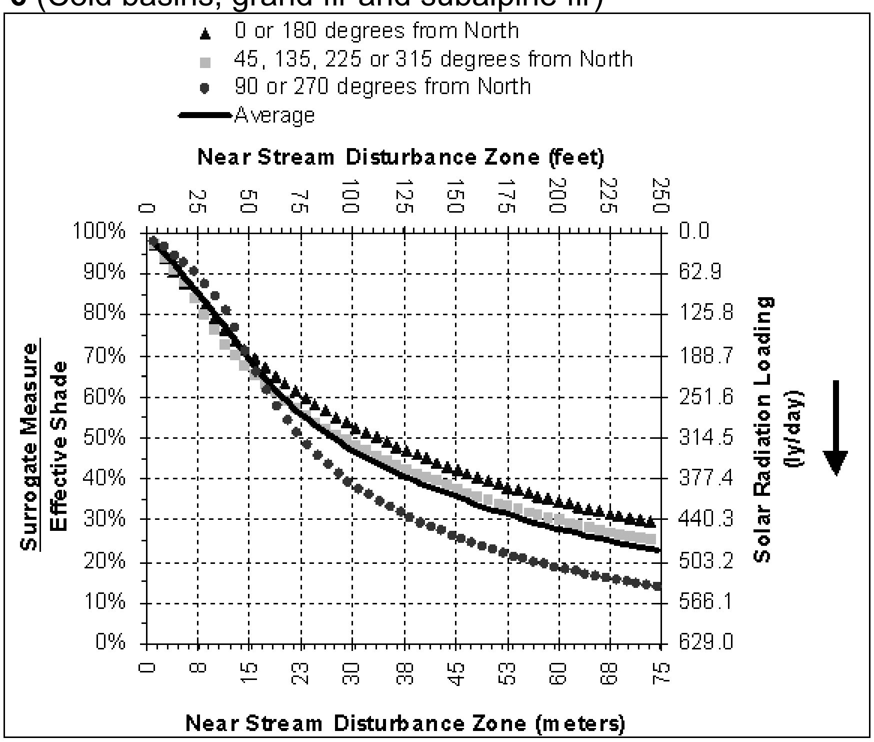
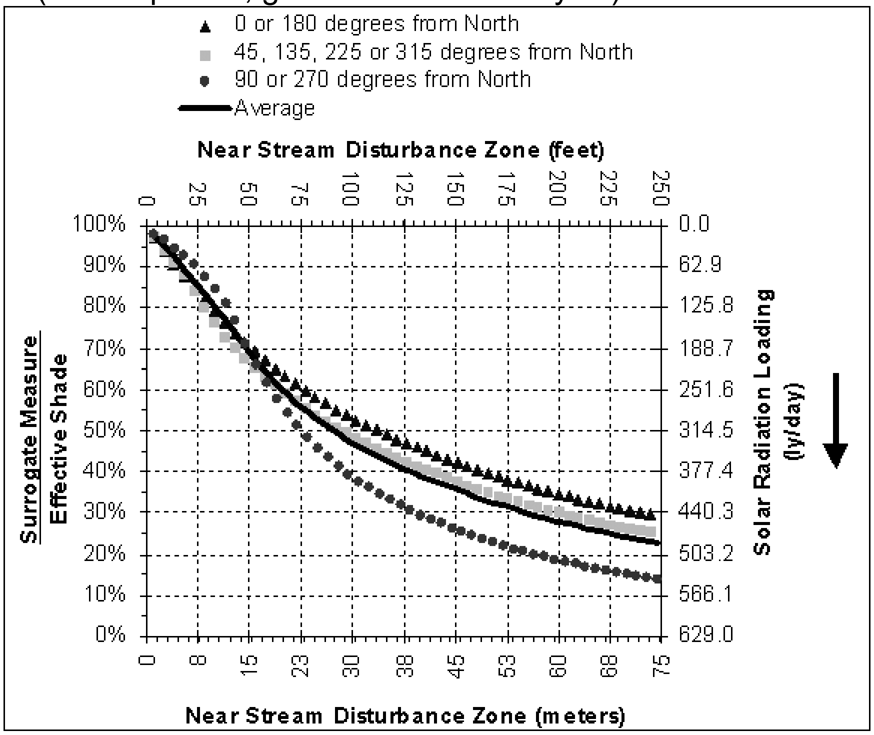


Figure F-20 (continued). Shade Curves Developed for Vegetation Response Units (VRUs)

VRU 7 (Moist uplands, grand fir and Pacific yew)



VRU 8 (Stream breaklands, cedar and grand fir)

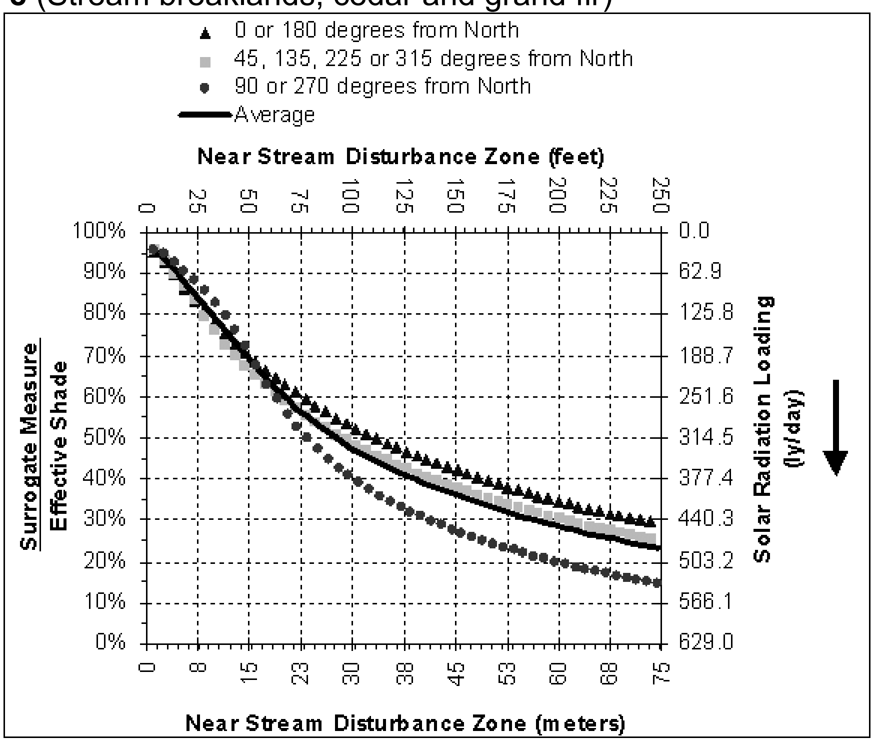
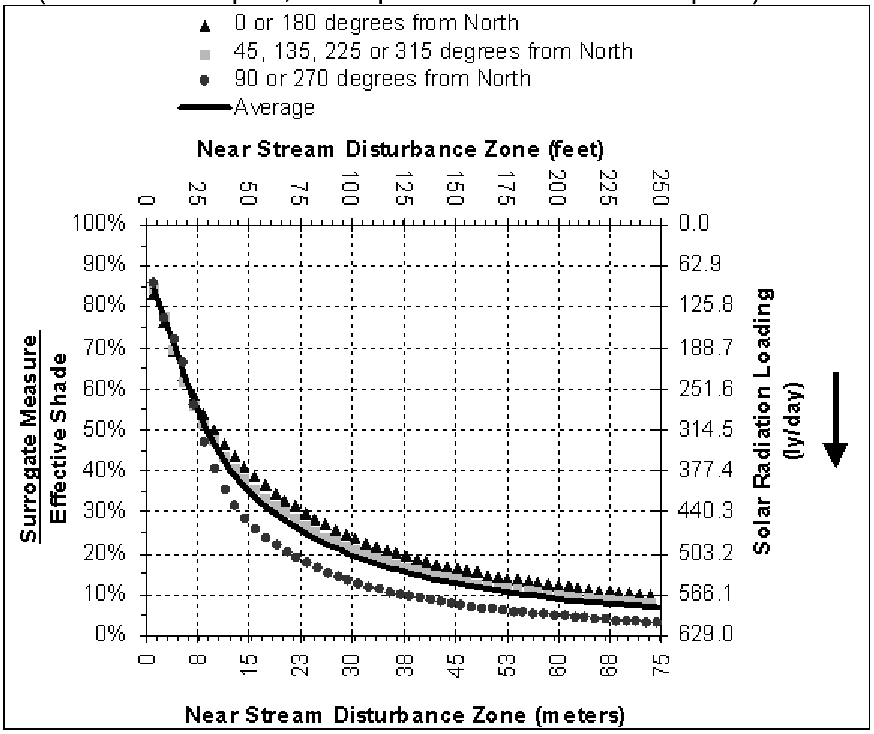


Figure F-20 (continued). Shade Curves Developed for Vegetation Response Units (VRUs)

VRU 9 (Glaciated slopes, subalpine fir and whitebark pine)



VRU 10 (Uplands, alder, grand fir and subalpine fir habitat types)

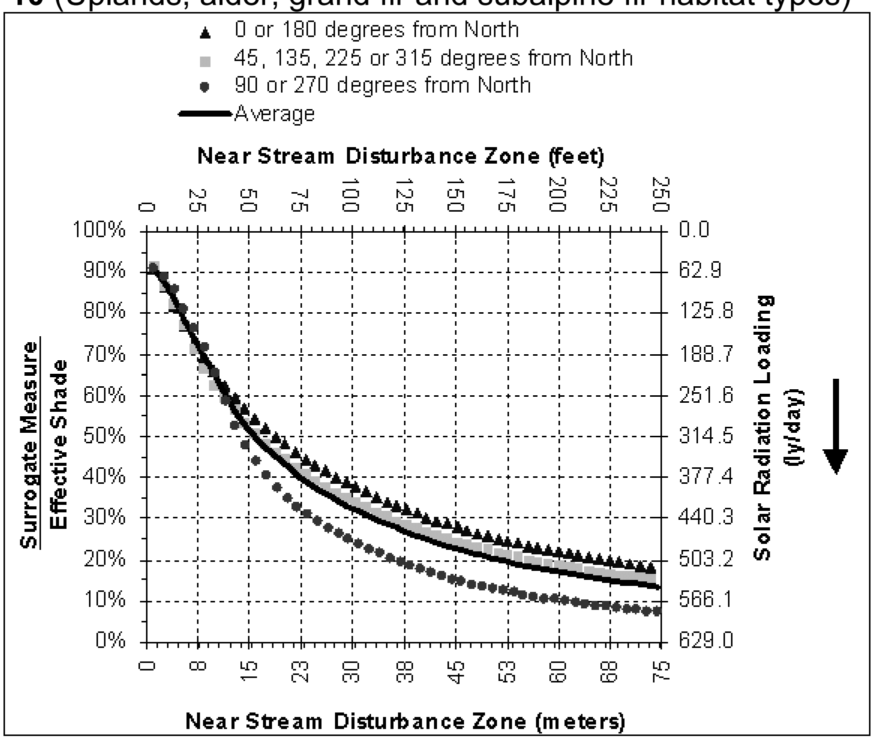
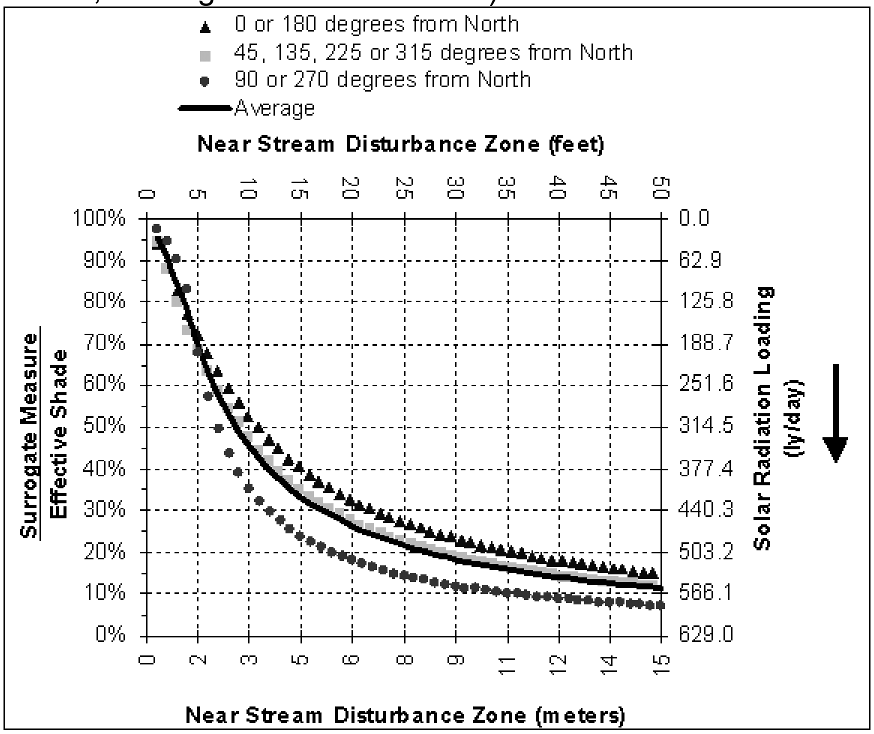


Figure F-20 (continued). Shade Curves Developed for Vegetation Response Units (VRUs)

VRU 12 (Stream breaklands, bunchgrass and shrubland) and
VRU 16 (Plateaus, bunchgrass and shrubland)



VRU 17 (Rolling hills, cedar and grand fir)

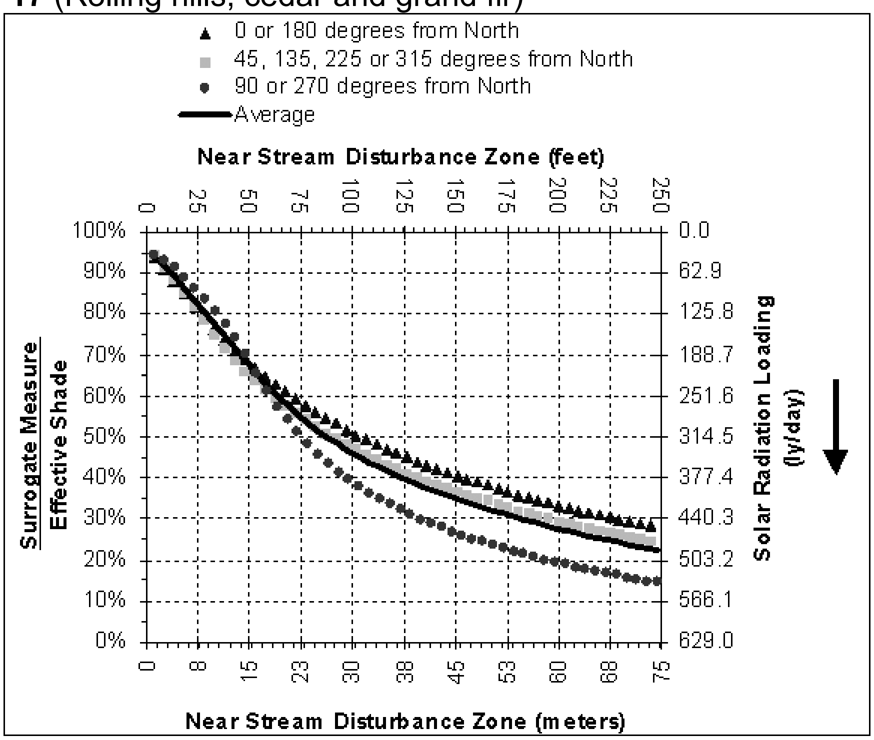
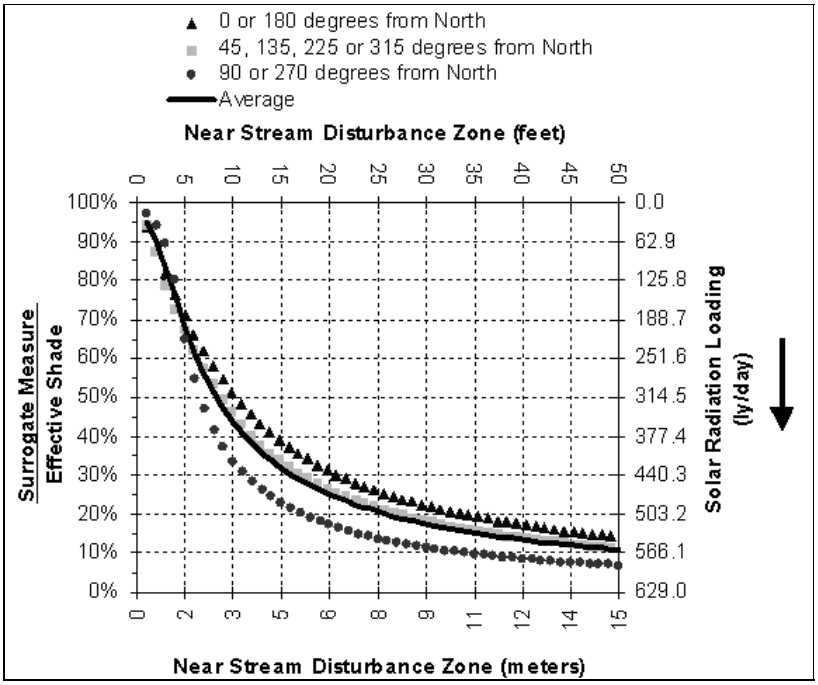


Figure F-20 (continued). Shade Curves Developed for Vegetation Response Units (VRUs)

Herbaceous/Scrub Wetland



Forest Wetland

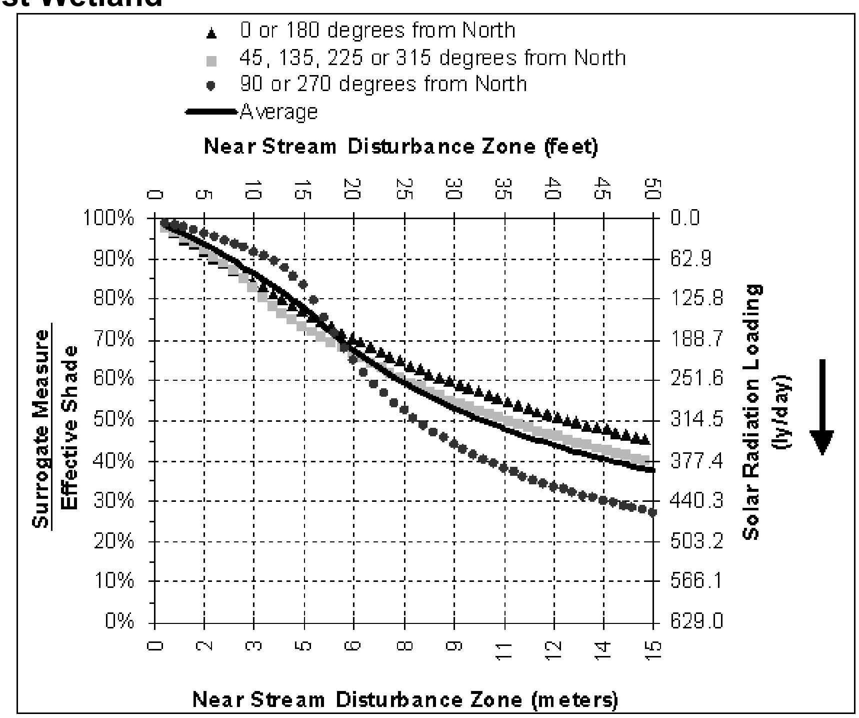


Figure F-20 (continued). Shade Curves Developed for Derived Wetland Areas

Spatial Allocation of Vegetation Land Cover

A determination of the spatial location of vegetation communities throughout the watershed is necessary to apply system potential effective shade in the South Fork Clearwater River Subbasin. Accordingly, the following rule set was used to determine this information.

The method utilized three main sources of information: 1) the HTG land cover data set, 2) the VRU land cover data set, and 3) the NWI land cover data set. The HTGs and VRUs are available for the entire subbasin and the NWI land cover data set is available for almost the entire watershed. Figures F-21 and F-22 illustrate the rule set described below.

"Forested" Communities–

Riparian community composition was developed from information provided within the VRU and HTG land cover data sets, while incorporating site-specific field data. The HTG land cover data set is at a higher spatial resolution than the VRU. However, the VRUs was developed specifically for the South Fork Clearwater River Subbasin to describe and develop an understanding of historic and current conditions and the development of target or desired landscapes.

Accordingly, vegetation composition used to develop system potential vegetation composition for "forested" areas was obtained from VRUs. However, the HTG land cover classification was used to spatially allocate "forested" and "non-forested" locations throughout the watershed. In addition, the NWI land cover classification was used to delineate wetlands areas.

"Non-Forested" Communities

Two VRUs are described as "non-forest" conditions (i.e., VRU 12 [Stream breaklands, bunchgrass and shrublands] and VRU 16 [Plateaus, bunchgrass and shrubland]). These two VRUs are primarily located within low elevation areas outside of NPNF boundary. Shrublands are the dominant vegetation within draws and lower slopes in these two VRUs. Once again, the HTG land cover classification was used to spatially allocate these "non-forest" locations throughout the watershed. In addition, the NWI was used to delineate wetlands areas within these coded "non-forested" areas.

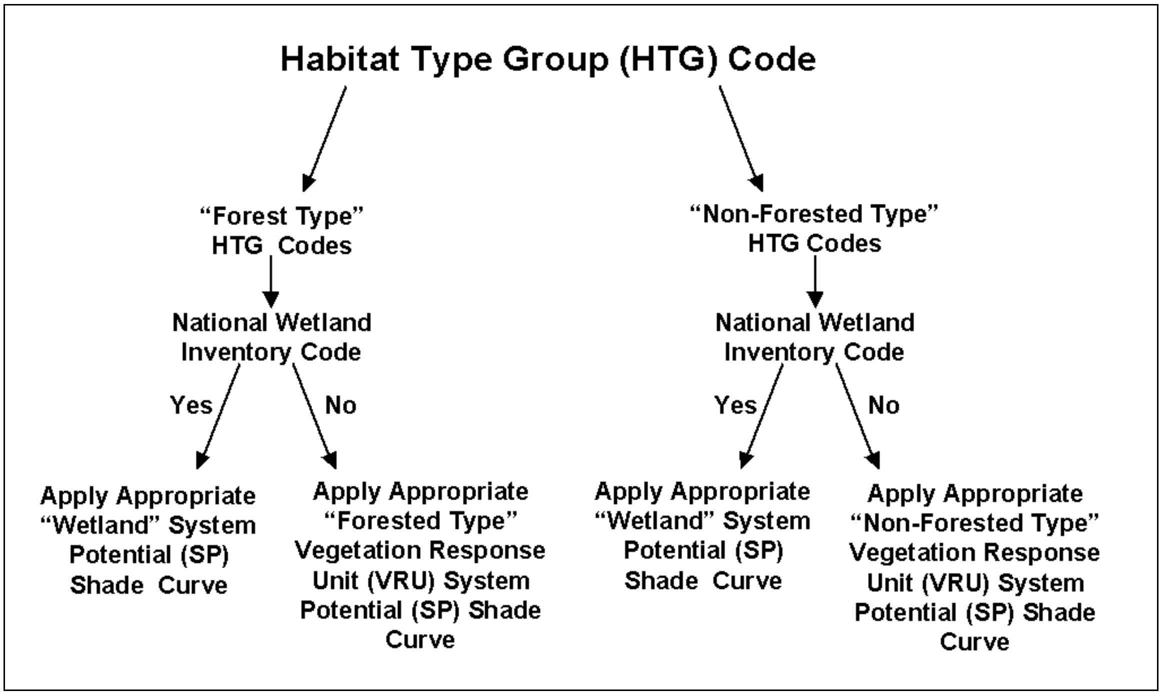


Figure F-21. Vegetation Composition Application Rule Set – South Fork Clearwater River Main Stem

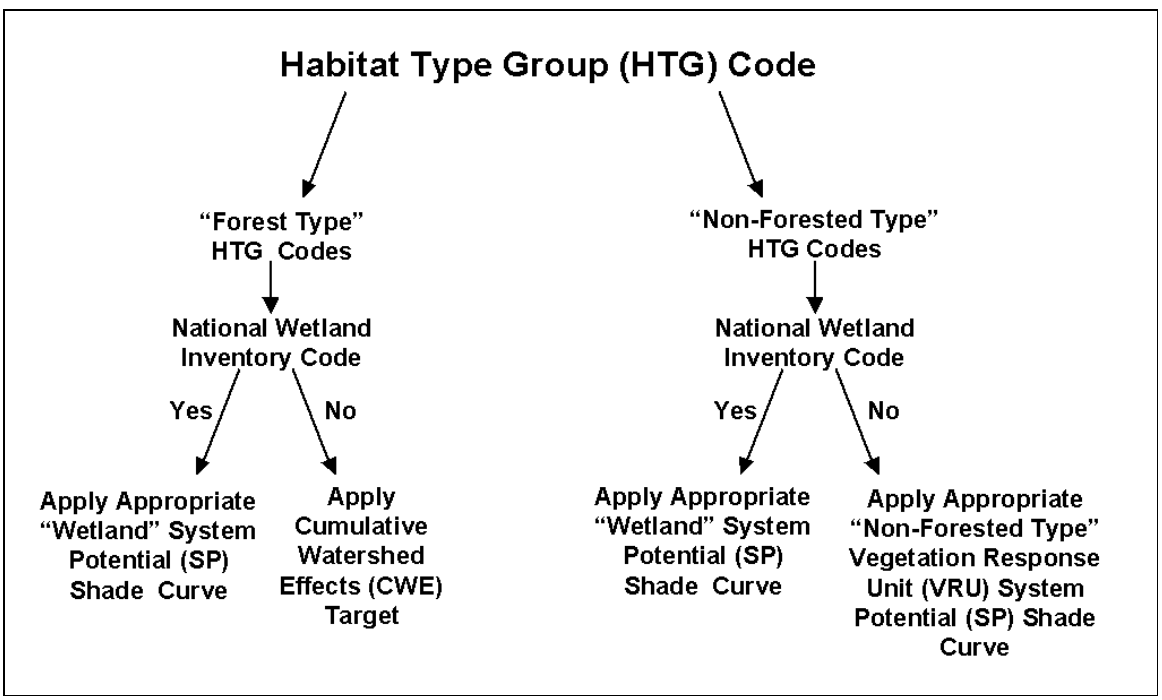


Figure F-22. Vegetation Composition Application Rule Set – Areas Other than the South Fork Clearwater River Main Stem

Site Specific Calculation of "System Potential Effective Shade"

The rule set illustrated above was applied to the South Fork Clearwater River and other tributaries throughout the subbasin. Specifically, system potential effective shade conditions for each 100-foot modeling reach was calculated using the system potential land cover condition derived using the VRU, HTG, and NWI data sets. In addition, all relevant landscape features impacting effective shade production were included in model development for each 100-foot segment (i.e., bankfull width [e.g., NSDZ], aspect, elevation, topographic shade angle, latitude, and longitude [see Figures F-6 through F-10]).

Using the rule set presented above, system potential effective shade conditions were calculated and are presented in Figure F-23. Current effective shade conditions, which were initially presented in Figure F-12, are also plotted on this figure.. System potential effective shade conditions presented in Figure F-23 utilize the same algorithms and vegetation community conditions used to develop the shade curves (see Figure F-21).

As can be seen in Figure F-23, observed current effective conditions are often similar to calculated system potential effective shade conditions; however, there are many areas where current levels are much below potential conditions. It is important to note that this line represents a 0.25-mile moving average condition from the 100-foot measurements. This was done so that general patterns in current and potential shade conditions could become more apparent in Figure F-23.

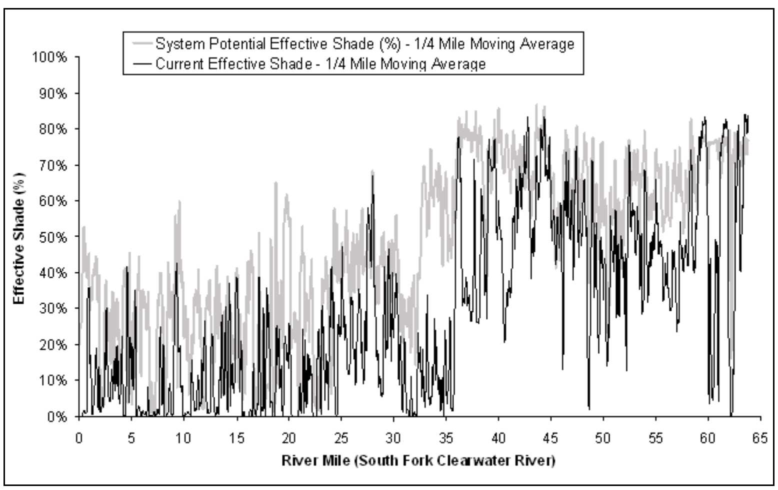
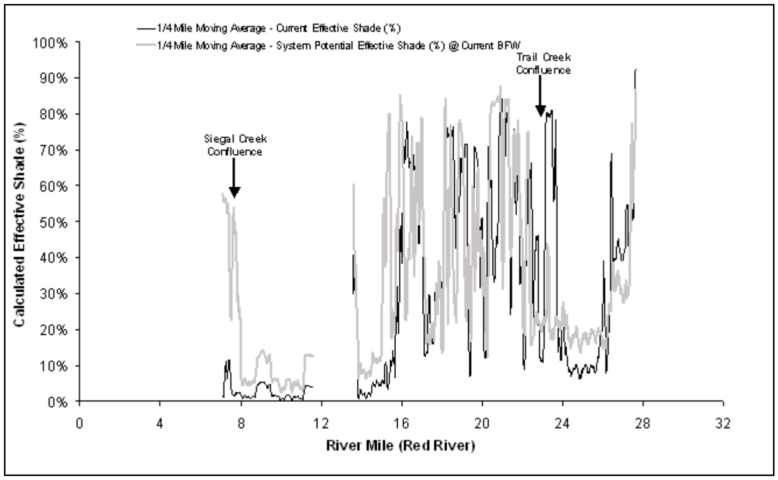
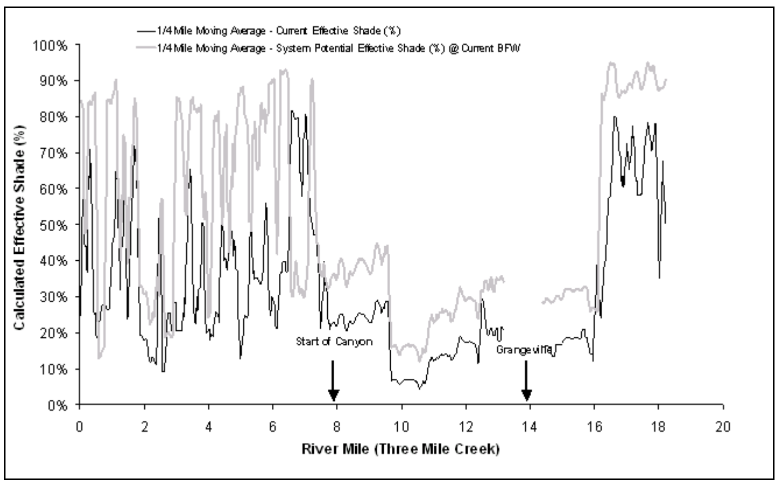


Figure F-23. Current and System Potential Effective Shade Conditions - South Fork Clearwater River and Major Tributaries





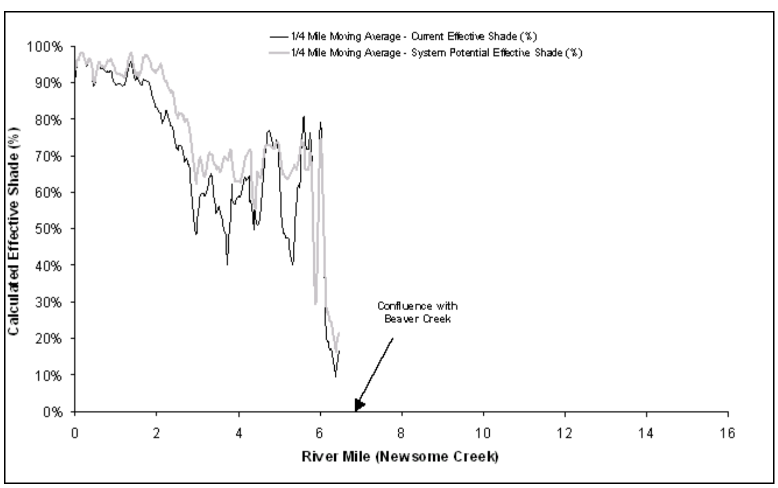
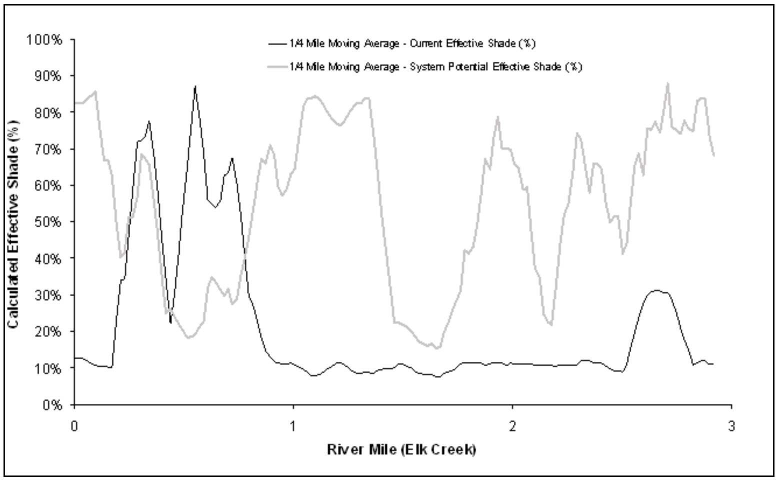


Figure F-23 (continued). Current and System Potential Effective Shade Conditions – Red River, Three Mile Creek, and Newsome Creek



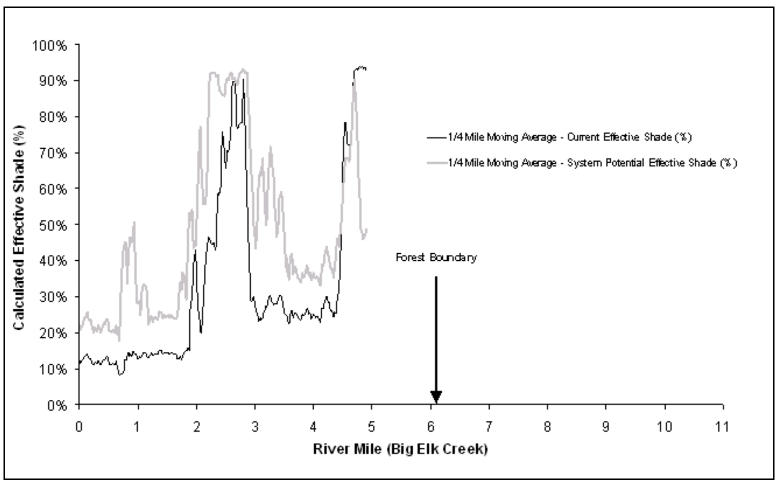


Figure F-23 (continued). Current and System Potential Effective Shade Conditions – Little Elk, Elk, and Big Elk Creeks

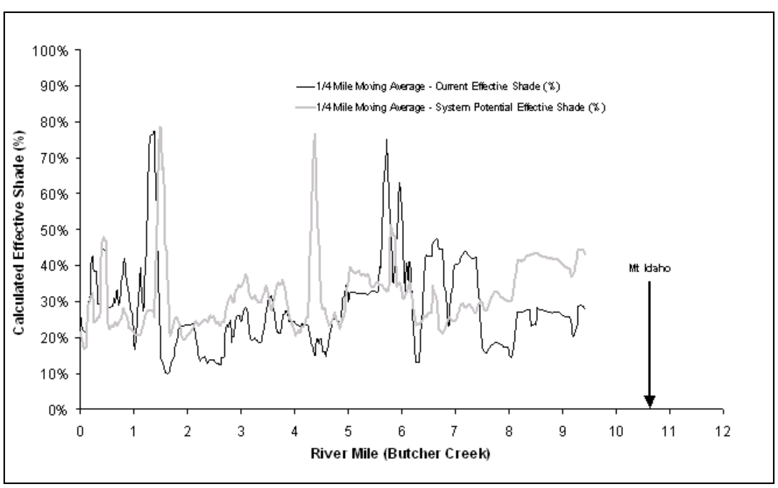


Figure F-23 (continued). Current and System Potential Effective Shade Conditions – Butcher Creek.

Temperature Impairments

Nine water bodies were identified in Chapter 3 as water quality limited due to temperature and are included in the Idaho 1998 303(d) List (Table F-10). As part of the TMDL effort for the South Fork Clearwater River Subbasin, hourly stream temperatures were measured at various locations throughout the watershed during the past several summers. Stream temperatures follow a longitudinal (downstream) heating pattern. All streams in the subbasin that have been monitored have been found to exceed temperature criteria, even though they are not all currently 303(d) listed. The goal of this effort is to achieve applicable temperature criteria and restore all of these to “full support of designated beneficial uses” (Idaho Code § 39.3611, 3615).

Table F-10. Water bodies included in Idaho 1998 303(d) list for temperature.

Water Body	Boundary
SF Clearwater River	Butcher Creek to mouth
SF Clearwater River	Johns Creek to Butcher Creek
SF Clearwater River	Johns Creek to Butcher Creek
SF Clearwater River	Tenmile Creek to Johns Creek
SF Clearwater River	Crooked River to Johns Creek
Threemile Creek	Confluence of Red River and American River to Crooked Creek
Butcher Creek	Source to mouth
Big Elk Creek	Source to mouth
Little Elk Creek	Source to mouth

Water Quality Standard Identification

The five water bodies of the South Fork Clearwater River main stem and Threemile Creek have designated beneficial uses of cold water aquatic life and salmonid spawning. Little Elk Creek, Big Elk Creek, and Butcher Creek have existing beneficial uses of cold water aquatic life and salmonid spawning. All these streams must therefore meet the cold water temperature criteria and meet the salmonid spawning temperature criteria when spawning occurs (Table F-11).

Table F-11. Applicable temperature criteria.

Beneficial Use	Criteria		Reference
Cold Water Aquatic Life	19°C (66.2°F) daily average	22°C (71.6°F) daily max.	IDAPA 58.01.02.250.02.b
Salmonid Spawning	9°C (48.2°F) daily average	13°C (55.4°F) daily max.	IDAPA 58.01.02.250.02.e.ii
Bull Trout	10°C (50°F) MWMT*		40 CFR Part 131.33(a)

*maximum weekly maximum temperature

In addition, USEPA has established temperature criteria for bull trout (Figure F-11) for a number of water bodies in the subbasin, including two which are 303(d) listed: Big Elk and Little Elk Creeks (See Appendix B for a full listing). These creeks must meet the federally-promulgated bull trout temperature criteria of 10 ^{o}C (50 ^{o}F) as an average of daily maximum temperatures over a seven day period (MWMT).

Seasonal Variation – Clean Water Act §303(d)(1)

Stream reaches within the South Fork Clearwater River Subbasin experience prolonged warming starting in late spring and extending into the fall. Maximum temperatures typically occur in July and August (see Figure F-11). The TMDL focuses the analysis during this critical period.

Nonpoint Source Component of Loading Capacity

Solar radiation load at system potential vegetation conditions is the loading capacity. Portions of the loading capacity are typically divided among natural, human, and future nonpoint pollutant sources. Table F-12 lists load allocations (i.e., distributions of the loading capacity) according to land use. In the South Fork Clearwater River Subbasin, the loading capacity of the system is all allocated to natural sources. No assimilative capacity exists for the other sources. This requires that nonpoint sources reduce temperature inputs to reach system potential conditions. The means of achieving these conditions is through restoring and protecting riparian vegetation and narrowing stream channel widths. The remainder of this section describes how those conditions are assessed.

Table F-12. Temperature allocation summary.

Nonpoint Sources	
Source	Loading Allocation Distribution of Solar Radiation Loading Capacity
Natural	100%
Agriculture	0%
Forestry	0%
Urban	0%
Future Sources	0%

Surrogate Measures and Nonpoint Source Load Allocations – 40 CFR § 130.2(i)

The South Fork Clearwater River Subbasin temperature TMDL incorporates measures other than “daily loads” to fulfill 303(d) requirements. Although a loading capacity for heat energy can be derived (e.g., Langleys per day), it is of limited value in guiding management activities needed to solve identified water quality problems. In addition to heat energy loads,

this TMDL allocates “other appropriate measures” (or surrogates measures) as provided under USEPA regulations (40 CFR
130.2(i)).

The *Report of the Federal Advisory Committee on the Total Maximum Daily Load (TMDL) Program* (FACA 1998) offers a discussion on the use of surrogate measures for TMDL development. The report says:

> “When the impairment is tied to a pollutant for which a numeric criterion is not possible, or where the impairment is identified but cannot be attributed to a single traditional “pollutant,” the state should try to identify another (surrogate) environmental indicator that can be used to develop a quantified TMDL, using numeric analytical techniques where they are available, and best professional judgment (BPJ) where they are not. The criterion must be designed to meet water quality standards, including the waterbody’s designated uses. The use of BPJ does not imply lack of rigor; it should make use of the “best” scientific information available, and should be conducted by “professionals.” When BPJ is used, care should be taken to document all assumptions, and BPJ-based decisions should be clearly explained to the public at the earliest possible stage.
>
> If they are used, surrogate environmental indicators should be clearly related to the water quality standard that the TMDL is designed to achieve. Use of a surrogate environmental parameter should require additional post-implementation verification that attainment of the surrogate parameter results in elimination of the impairment. If not, a procedure should be in place to modify the surrogate parameter or to select a different or additional surrogate parameter and to impose additional remedial measures to eliminate the impairment.”

The nonpoint source assessment presented above demonstrated that stream temperatures warm as a result of increased solar radiation loads, due to anthropogenic disturbances to near-stream vegetation and channel morphology. A loading capacity for radiant heat energy (i.e., incoming solar radiation) can be used to define a reduction target that forms the basis for identifying a surrogate. The specific surrogate used is percent effective shade (expressed as the percent reduction in potential solar radiation load delivered to the water surface).

Factors that affect water temperature are interrelated. The surrogate measures (percent effective shade and channel width) rely on restoring and protecting riparian vegetation to increase stream surface shade levels and reducing the NSDZ width by reducing stream bank erosion and stabilizing channels.This will reduce the surface area of the stream exposed to radiant energy. Shade is more effective on narrow streams than on wider streams given the same flow of water at a given point because shadows cast by trees cover a greater percentage of the stream surface in narrow streams. Effective shade screens the water’s surface from direct rays of the sun. Highly shaded streams often experience cooler stream temperatures than similar, but less shaded streams, due to reduced solar radiation input (Brown 1969, Beschta et al. 1987, Holaday 1992, Li et al. 1994). Accordingly, the surrogate measure used in this portion of the temperature TMDL is “system potential effective shade.”

Over the years, the term, “shade,” has been used in several contexts, including its components such as shade angle or shade density. For purposes of this TMDL, shade is defined as the percent reduction of potential direct beam solar radiation load delivered to the water surface. Thus, the role of effective shade in this TMDL is to prevent or reduce heating by solar radiation and serve as a linear translator to the solar loading capacities. Effective shade is presented in greater detail in Appendix I.

Channel width is only evaluated within this TMDL as a function of stream effective shade production. It is expected that factors and efforts associated with achieving effective shade targets will promote channel recovery and improvement. That is, effective shade allocations associated with this TMDL will achieve, through passive restoration, system potential channel width conditions. One exception is that areas with serious channel alteration due to past mining may require active reconfiguration to achieve desired channel conditions. A specific target is not set for this parameter, but it is expected that these areas will be identified in the TMDL implementation plan along with appropriate restoration strategies.

Effective Shade Surrogate Measures

The loading allocation is defined in Langleys per day, which is a unit of energy calculated by the shade calculator (i.e., Heat Source 6.5 [Boyd 1996]). However, a load allocation in terms of Langleys per day is not very useful in guiding nonpoint source management practices. Fortunately, percent effective shade is a surrogate measure that can be calculated directly from the loading capacity (i.e., Langleys per day). Percent effective shade is simple to quantify in the field or through mathematical calculations. Figure F-20 displayed derived effective shade curves for the South Fork Clearwater River Subbasin. Specifically, given a measured or estimated channel width (or NSDZ) and the directional aspect of a stream, the percent effective shade or the solar radiation loading can be estimated from the data in Figure F-24. (Effective shade is plotted on the left y-axis, and the associated heat load in Langleys per day is plotted on the right y-axis on this figure.) Langleys per day presented in this figure is the load capacity.

Shade curves were applied to site-specific areas using the rule sets illustrated in Figures F-21 and F-22. Figure F-24 illustrates the calculated system potential effective shade presented in Figure F-23 and the corresponding energy in Langleys per day.

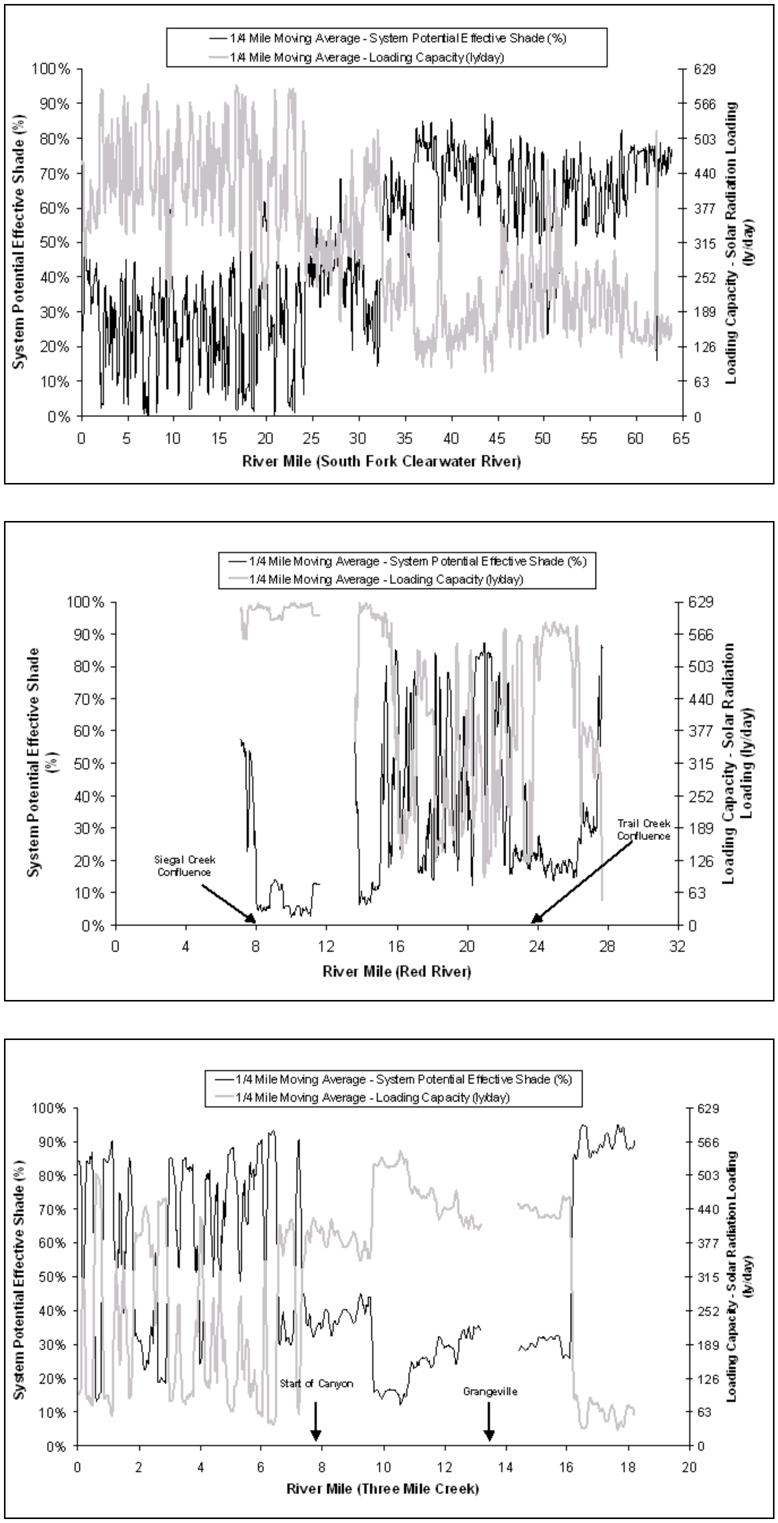


Figure F-24. System Potential Effective Shade and Loading Capacity – South Fork Clearwater River, Red River and Three Mile Creek

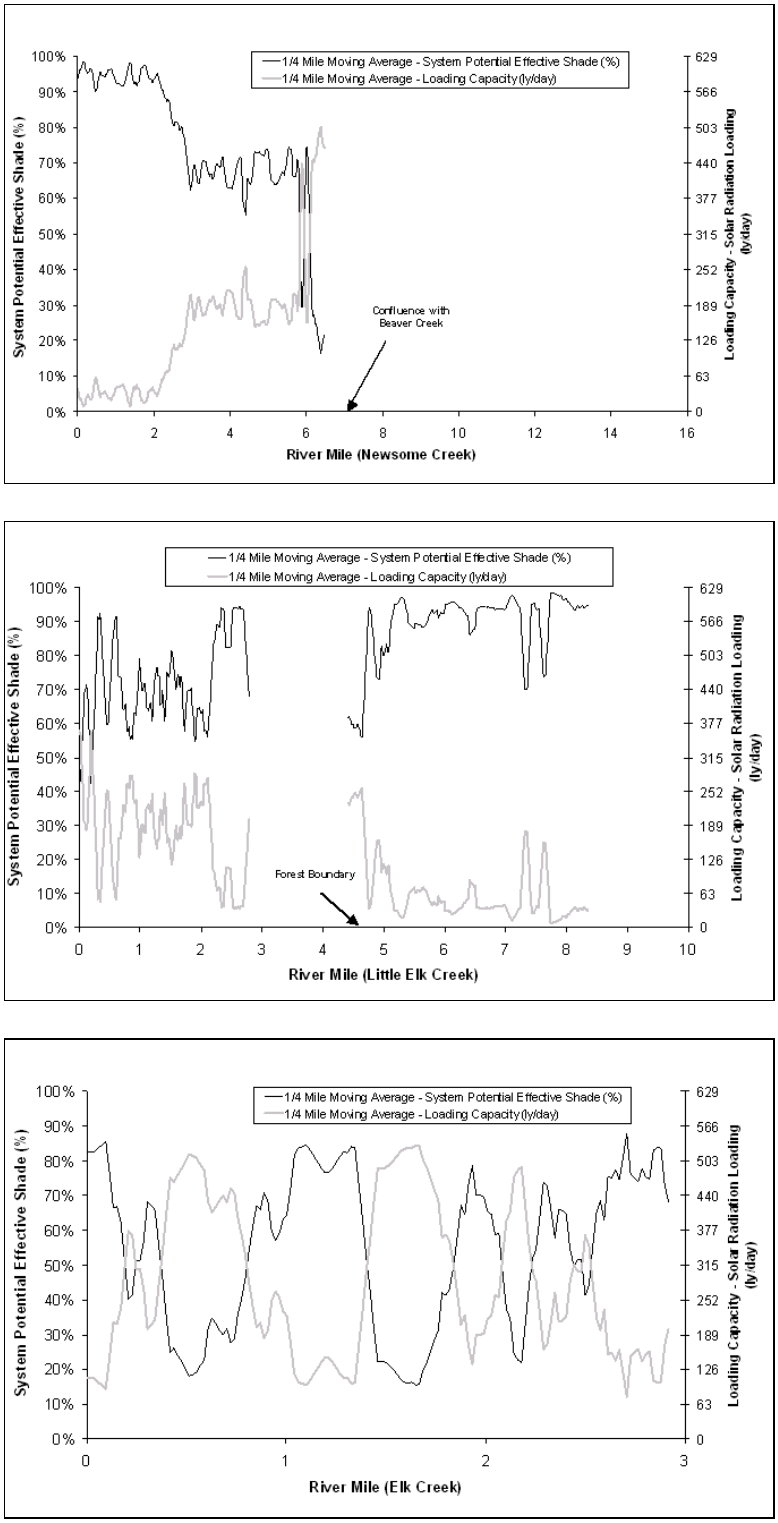
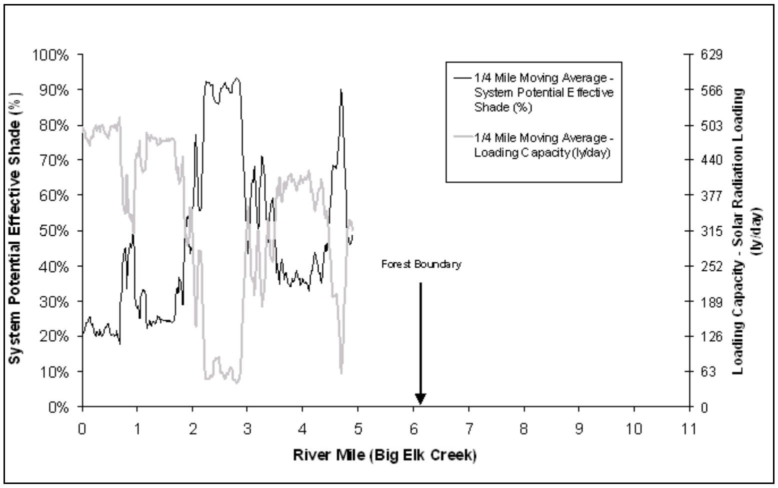


Figure F-24 (continued). System Potential Effective Shade and Loading Capacity –Newsome Creek, Little Elk Creek, and Elk Creek



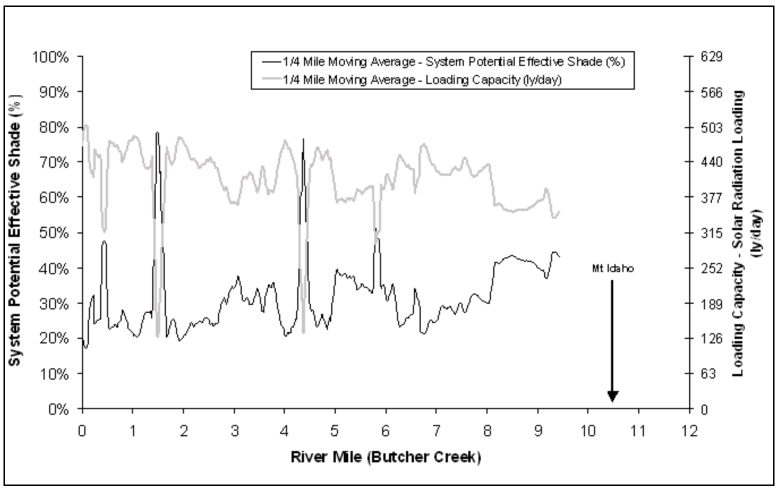


Figure F-24 (continued). System Potential Effective Shade and Loading Capacity –Big Elk Creek and Butcher Creek

Margins of Safety – Clean Water Act §303(d)(1)

The Clean Water Act requires that each TMDL be established with a margin of safety (MOS). The statutory requirement that TMDLs incorporate an MOS is intended to account for uncertainty in available data or in the actual effect controls will have on loading reductions and receiving water quality. An MOS is expressed as unallocated assimilative capacity or conservative analytical assumptions used in establishing the TMDL (e.g., derivation of numeric targets, modeling assumptions, or effectiveness of proposed management actions).

The MOS may be implicit, as in conservative assumptions used in calculating the loading capacity, wasteload allocation, and load allocations. The MOS may also be explicitly stated as an added, separate quantity in the TMDL calculation. In any case, assumptions should be stated and the basis behind the MOS documented. The MOS is not meant to compensate for a failure to consider factors that effect water quality.

A TMDL and associated MOS, which result in an overall allocation, represents the best estimate of how standards can be achieved. The selection of the MOS should clarify the implications for monitoring and implementation planning in refining the estimate if necessary (adaptive management). The TMDL process accommodates the ability to track and ultimately refine assumptions within the TMDL implementation/planning component (Table F-13).

Table F-13. Approaches for incorporating a margin of safety into a TMDL.

Type of Margin of Safety	Available Approaches
Explicit	Set numeric targets at more conservative levels than analytical results indicate. Add a safety factor to pollutant loading estimates. Do not allocate a portion of available loading capacity; reserve for margin of safety.
Implicit	Make conservative assumptions in derivation of numeric targets. Make conservative assumptions when developing numeric model applications. Make conservative assumptions when analyzing prospective feasibility of practices and restoration activities.

The following factors may be considered in evaluating and deriving an appropriate MOS:

- The analysis and techniques used in evaluating the components of the TMDL process and deriving an allocation scheme.
- Characterization and estimates of source loading (e.g., confidence regarding data limitations, analysis limitations, or assumptions).
- Analysis of relationships between the source loading and instream impact.
- Prediction of response of receiving waters under various allocation scenarios (e.g., the predictive capability of the analysis, simplifications in the selected techniques).
- The implications of the MOS on the overall load reductions identified in terms of reduction feasibility and implementation time frames.

Calculating a numeric MOS is not easily performed with the methodology presented in this document. However, the TMDL accounts for uncertainties in the analysis by incorporating an implicit margin of safety.

By definition, system potential effective shade, developed from system potential vegetation conditions, is the highest level of shade achievable; and therefore, represents an implicit MOS.

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